Report of the

TWENTIETH SOUTHERN PASTURE AND FORAGE CROP IMPROVEMENT CONFERENCE

Auburn University
Auburn, Alabama

May 1-2, 1963

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TWENTIETH SOUTHERN PASTURE AND FORAGE CROP IMPROVEMENT CONFERENCE[1/]

Auburn University
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PROGRAM

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Wednesday - May 1 - Morning

R. M. Patterson, Presiding

Opening Session

The twentieth meeting of the Southern Pasture and Forage Crop Improvement Conference was officially opened by Conference Chairman, Dr. R. M. Patterson, who introduced Dr. E. V. Smith, Dean and Director, to welcome the group to Alabama. Dean Smith gave interesting reminiscences on the old agronomy tours of the South which set the stage for the formation of the Southern Forage Crop Improvement Conference. He observed that since the formation of this conference there has been an almost complete replacement of the traditional row crop agriculture of the South, with a new diversified agriculture in which grasslands and livestock play an important role. Dean Smith paid tribute to the agriculturists of the South who have been instrumental in affecting this important transformation. He extended a most cordial welcome to each member of the conference and expressed his hope that the important deliberations of this conference would be even greater benefit to the South.

Chairman Patterson introduced the members by states. Members attending are:

Alabama	37	Georgia	17	Mississippi	9	Puerto Rico	1
Arkansas	1	Kentucky	3	New York	1	So. Carolina	11
Australia	1	Louisiana	2	No. Carolina	7	Tennessee	3
Florida	7	Maryland	6	Oklahoma	2	Texas	5
						Virginia	4

In presenting the keynote speakers, Chairman Patterson charged this conference with "Improvement of forage and feed crop production and utilization in the Southeast." The keynote speakers Dr. Howard Rogers, Head, Agronomy and Soils Department and Dr. W. M. Warren, Head, Animal Science Department, Auburn University were introduced.

Keynote Addresses - Howard T. Rogers

Up until 10 to 12 years ago some livestock authorities seriously questioned whether there would ever be a stable livestock industry established in the Old Cotton Belt--primarily because of the costs of growing quality forage and parasite and disease problems. Certainly the rate of growth in the last 10 years and the numbers of cattle belie any such predictions.

In spite of this increase, some well-respected economists can prove there is little or no profit in beef production in Alabama at present costs and prices--if there is a reasonable charge made for capital invested in land. Ellis and Partenheimer (1), for instance, estimated that a 100-cow herd in an "improved" system in the Limestone Valley of North Alabama might return to land and management about $2,500/year. This would require 2-1/4 acres per cow and would leave little for management if reasonable interest is charged on investment. A similar system in the Lower Coastal Plains would return only $600 to land and management. (This would provide 2% on investment and nothing to management.) Similar studies in Mississippi showed that returns to land and management ranged from $400 to $1,700/year from 100 acres in a cow-calf system, depending on level of management.

You might ask me, why worry about these cost estimates when the "figures" show how fast the cattle industry is growing? Because I was asked to discuss "Agronomic problems in forage production in the region"--first I wanted to be sure that you were convinced that we have some problems in forage production. I would much rather talk about opportunities and potentials and, of course, I hope each of you will view these problems as opportunities and challenges.

I might have started this talk by quoting--see if this sounds like an agronomist--"Livestock producers in the South must meet the challenge of developing more effective programs for producing low-cost forage and other feeds. Better adapted grasses for providing forage in the normally dry summer and fall months are needed, or high tonnage crops need to be produced, stored and fed during these periods. Yield and quality of grain crops and roughages must be raised." However, this was another of our economists, Homer Blackstone, speaking before the American Farm Economics Association--and I'm glad to quote him.

Having just come through one of the worst winters in a century, our livestock growers are now taking hay production seriously. While in numerous experiments we have produced, without irrigation, 8 to 12 tons of Coastal hay per acre, the average yield of all hay in Alabama is still discouragingly low. Progress has been much greater with nearly every other crop grown; the disparity is greatest with corn and cotton.

Dr. Coyt Wilson, our Associate Director, has asked our agronomists, several times, whether the rates of fertilizer and lime recommended for clover-grass pastures are "economical" for the beef grower. We say this is what is needed to grow these species on Alabama soils. I am not sure anyone can prove the recommendations to be economical. Likewise, I am not sure anyone can prove beef cattle production in the Southeast to be profitable, but more and more people are having "fun" trying.

However, let's be specific on some questions which need serious study (creative imagination plus industrious curiosity) by all of us:

1. In forage crop breeding--should we attempt to improve the quality of species which are inherently well adapted to the soil and climate of the region but which have low digestibility and/or palatability, or should we work toward the development of better adapted varieties of those forages which we know have high digestibility and palatability? This would be a good question for a half-day symposium.

2. What is the future for clover-grass pastures in the region? We have seen white clover gradually decline in many parts of the area. It is difficult and perhaps more expensive to maintain a legume in these perennial grasses than to use commercial nitrogen, but is there value to legumes in the mixture beyond nitrogen fixation? I am convinced we will see much cheaper commercial nitrogen soon. By 1965, we expect a production capacity in this country for 6 million tons of N compared to last year's use of only 3 million tons. The challenge may well be, can legumes compete with 5¢ N?

3. What should we use for a cool season perennial grass? Can a beef cattle system afford annual seeded winter crops?

4. Back to an earlier statement--"We need low-cost forage production first, and then all of the quality we can get." Some farmers are utilizing the whole corn plant--not as silage, but after combining the grain. Have we ever tried to produce a variety of corn for this purpose? What is the maximum tonnage per acre we can get from corn? Suppose we use South American varieties that grow 20 feet tall, and are willing to sacrifice grain yield for total dry matter. Do South and Central America have more to offer as source material in forages than New England or the Corn Belt? Perhaps we may get farther by looking southward in our forage work.

W. M. Warren

I am pleased to be with you for the first time and to welcome you to Auburn. I remember one of my first impressions of livestock utilization in the Southeast occurred in December 1945 while driving from Athens, Georgia to College Station, Texas. As I compare that observation with what we see today, a remarkable change in Alabama in the last nine years has taken place in livestock enterprises. Today we see a more adequate feed supply for livestock; a much better utilization of our grasslands is also immediately apparent. We must take advantage of the inherent opportunities in the South for livestock production and minimize our disadvantages to develop profitable livestock enterprises. Agronomists have produced a variety of improved pasture plants and our challenge is to utilize these plants in competition with producers in other areas to produce livestock economically. Alabama is a grain deficient area. We must rely heavily on forages. We can produce productive forages though the nutritive value is sometimes lower than desired.

What are some of the problems which we face today? Sorghum silage is high producing yet livestock performance is erratic. Several of our forage crops, while high producing, lack nutritive value. Nitrogen fertilization does not always improve forage quality. The variation in performance in beef steers is too narrow yet occasionally there are high gainers, up to four pounds per day. We need to know if the ceiling on gains can be raised. Alabama has average calf crop of only 81 percent. Another area of challenge, both beef and pork are too fat for the housewife. Beef cattle are major users of forage in the Southeast hence we must have a closer liaison between animal husbandry and agronomists if we are to develop a profitable livestock economy in Southeastern United States.

Business Session - Chairman Patterson, Presiding

Chairman Patterson appointed the following committees to report at the final business session: Resolutions, W. E. Knight, Chairman, L. H. Taylor, M. E. McCullough; Nominations, M. S. Offutt, Chairman, C. B. Browning, R. E. Blaser; C. S. Hoveland, transportation coordinator; and E. M. Evans, banquet ticket disbursing agent. Meeting of the Executive Committee was scheduled for 8:30 p.m. and the chairman of S-45, 46, and 47 Technical Committees were invited to attend. Chairman Patterson then introduced the tour leaders for announcements concerning the afternoon field tours. G. H. Rollins gave information for the animal science

group and D. G. Sturkie gave instructions for the plant science tour. Assembly in front of Duncan Hall at 1:00 p.m.

Wednesday - May 1 - Afternoon

Animal Science Group Tour

Stops on this interesting tour included poultry farm with a discussion on environmental physiology, Dr. J. R. Howes; inspection of animal nutrition facilities, Dr. W. B. Anthony, Leader; dairy nutrition research esophageal fistulated cattle, parotid gland fistulate cattle, and other ruminant research facilities, Drs. K. M. Autrey and G. E. Hawkins; pasture research at the North Auburn Dairy Unit, Dr. G. H. Rollins; and feed processing including pelleting, Dr. R. R. Harris.

Plant Science Group Tour

This tour included stops at the agronomy farm, turf research by Dr. D. G. Sturkie; reseeding vetch study, E. D. Donnelly; at Alvis field of sorghum almum winter survival, R. M. Patterson; Bermudagrass management, E. M. Evans; agronomy greenhouse, W. C. Johnson; and agronomy growth chambers, E. E. Scarsbrook and Z. F. Lund.

Thursday - May 2

JOINT SESSION
Homer D. Wells, Georgia, Presiding

Panel Discussion - Providing the spring, summer, fall and winter forage needs for a cow-calf beef production program in the:

<u>North humid section</u> - T. H. Taylor

This region has a humid mesothermal climate making it possible to grow Kentucky bluegrass, tall fescue, orchardgrass, alfalfa, red and white clovers, and annual lespedeza, as well as cereal crops and summer annual grasses. The topography varies from peneplains to great mountain ranges. For the most part, the soils are residual and in the gray-brown podzolic group. The productive capacity of the soils varies from high to very low, requiring sound liming and fertility practices be done on a very local basis.

A large number of forage programs are recommended and practiced in the region. This is to be expected because of the diverse soils, large number of plants that may be grown, and the wishes and habits of individual farmers. However, the 2 most used base grasses are tall fescue and Kentucky bluegrass, and the most used legumes are white clover and annual lespedeza. The ecology of these grass-legume associations under grazing make possible their wide use by beef brood cow producers.

Supplementation during the growing season is more necessary on fescue-legume or straight fescue pastures than on bluegrass-legume or bluegrass pastures. Under good management, animals may be expected to graze for 7 months of the year. Stored winter feed is essential for the other 5 months.

<u>Piedmont section</u> - W. W. Woodhouse and H. D. Gross*

The Piedmont region encompasses a considerable range of conditions since it extends from Virginia to Alabama. It would seem to be more meaningful, therefore, to restrict this discussion to a more manageable portion of the area, namely that of Piedmont North Carolina.

Traditionally, the Piedmont has been a row-crop (cotton) area. This has resulted in depleted and eroded soils, silted-in reservoirs and a heavy silt load in our rivers. Many acres, of necessity, have been abandoned or are presently in trees or sod.

The majority of these soils will support row-crop production sometime in the rotation. However, most of them should not be seeded to intertilled crops a majority of the time. For this reason, the recent trend toward row-crop silage and on-the-farm concentrate production is aggravating the land use problem in this region.

* Paper presented by H. D. Gross

In the light of these facts we have built our cow-calf forage program around perennial sod crops. It has been well established that straight grasses, heavily fertilized with nitrogen, have a very high carrying capacity. However, experience, plus research currently in progrress, indicate that cows milk better and calves wean at higher weights and in better condition if some legume is included in the system.

Stored forage in the form of hay or silage can easily be worked into the total scheme. Hay would be best, perhaps for the smaller herds, but the choice between these two is a matter of local decision. Hay and/or grass silage can be made from the forage surplus usually experienced during the spring flush. Usually a row-crop, such as corn or sorghu, is used in the renovation scheme or as an integral part of the rotation. It is quite feasible to use such a crop to meet the silage requirement of the proposed program.

Based on our date to date, the following represents our best judgment for a cow-calf forage program in the N. C. Piedmont:

Grazing:

Per cow: - 1 A Ladino-fescue or Ladino-orchard

plus

1/4 A Coastal bermuda or 1 A lespedeza

plus

1/4 A Fescue or small grain with or without ryegrass or crimson clover

Stored feed:

Per cow: - 1 ton of hay

or

2 1/2 tons silage

or

any combination of the above

This is the program agreed upon and now being advocated by the extension specialists in Animal Husbandry, Crop Science and Soil Science for the Piedmont region of North Carolina.

Semi-arid to arid sections - E. C. Holt

In a cow and calf program a continuous feed supply for the entire year is necessary. Admittedly not nearly all herds have an adequate supply of feed. Good pastures are the most economical source of feed for the herd, so every effort should

be made toward establishing and managing year-around pastures for grazing. Many cow and calf operations in Central Texas and certainly further westward depend almost entirely on native or perennial pastures and supplemental feed. This type of program is well adapted to the dry areas because it requires much less investment, and therefore the loss risks are less. Temporary and supplemental pastures require farm equipment often not found, especially on ranches. Because of the limitations of this type of program most of this presentation will deal with production conditions in Central Texas.

Central Texas is a natural small grain producing area, thus small grain can be used for fall and mid-winter grazing following which a grain crop can be harvested. The average farm livestock cow and calf operation in Central Texas follows a general forage and grazing program along the following lines. Small grain grazing from December to May; native or perennial pasture in the spring; sudan, sorghum, millet, or Johnsongrass in mid-summer; sorghum or sudan regrowth following hay or silage in late summer and fall; native pasture in late fall and winter. During late summer and again in mid-winter there are periods when grazing is short or low in quality. Supplemental feeding must be planned for these periods. In East Texas and the Gulf Coast where summer rainfall is better, supplemental summer pastures are used to less extent, but winter pastures of small grain or ryegrass are used.

Year-around forage production is possible only in those years when the weather cooperates. An early planting of small grain will meet part of the early winter forage needs when moisture is adequate for small grain emergence and growth. Limited moisture may create periods of forage deficiency anytime during the year, especially in mid-summer and early winter. Extended cold periods and freeze damage may limit forage availability in January and February.

The objectives of the beef cattle and pasture research programs at the McGregor Station in the Grand Prairie area of Central Texas are the production of 1000-pound animals on the farm or ranch at 12 months age. This program requires the selection of mother cows with adequate milk producing ability to wean heavy calves, sires with high inherent gaining ability, heterosis from cross breeding, good pastures, a breeding program timed to take advantage of available forage, and feeding period of 110 to 120 days. The forage program includes, as already indicated, small grain pastures, native cool-season grasses, summer supplemental pastures of sudan hybrids, native pasture, crop residues, and hay or silage.

Delta section - P. G. Hogg

The beef cow-calf feed program in the Mississippi Delta is based on Coastal Bermuda for the summer and tall fescue for the winter. Rough peas and white clover are the most important legumes and are used in combination with both Coastal and fescue. Coastal-legume pastures have produced beef in, on-the-farm studies at 1/3 the cost of other summer grasses. This is chiefly due to the fact that legumes persist better in Coastal than in common bermuda and that Coastal requires very little grazing management. Coastal also provides a cheap source of hay for winter feeding of the cow herd. Recommended ratio of Coastal to fescue is 2 to 1, this ratio will vary on individual farms depending on the amount of stalk field available for winter feed.

Coastal Plain section - Glenn W. Burton

Perhaps no section of the United States has so wide a choice of species that will provide feed for the cow-calf beef production program. In addition to the several hundred species that make up the native range, there are well over two dozen introduced species that may be used. Although few would agree on the choice of species, all would agree that such forages must be: (1) dependable, (2) economical, (3) efficient in use of water and fertilizer, (4) safe, and (5) versatile. Table 1 proves that even the better grasses differ materially in dependability, efficiency of production and thus economy of production.

Table 1. Effect of drought on 4 grasses growing on well-fertilized deep sand at Tifton, Georgia.

Grass	Dry matter yield tons/acre	
	1953	1954
Common bermuda	3.2	0.5
Coastal bermuda	6.2	3.1
Suwannee bermuda	7.1	4.4
Pensacola bahia	5.7	1.6
Rainfall in inches	39.7	13.7

All grasses were uniformly fertilized.

To have enough feed in the dry years, the cattleman must stock his pastures for the dry years or provide stored feed. The ranch stocked for the dry years would have 6 times as much grass as needed in the wet years if common bermudagrass were used. If Coastal or Suwannee bermudagrass were used, it would have about twice as much as needed and the surplus with these more versatile grasses could be cut and sold as hay.

The low margin of profit in the cow-calf program will not allow for the loss of many animals due to bloat, HCN, or nitrate poisoning.

Forages that are versatile enough to make hay or silage, as well as pasture, will be much more valuable than those only suited for grazing.

The lack of adapted, dependable legumes makes the use of perennial grasses the best source of forage for the cow and calf program from April 15 to November 15. Research from several states indicates that for moderate to well drained sites Coastal bermuda leads other perennials if judged by the five criteria mentioned above.

In three years out of four, rainfall at Tifton, Georgia, in either October or November is less than 1 inch and in one year out of three, total rainfall for

October and November is less than 1.6 inches. This is not adequate to successfully establish cool-season annuals for winter grazing.

One year in three, mean monthly temperatures at Tifton are around 45 degrees for at least one month. None of the cereals or cool-season forages will make any appreciable growth at such temperatures. Two years in three, mean monthly temperatures are below 50 degrees at least one month, and then small grains make only about one-fourth the growth they make at optimum temperatures.

This weather pattern makes winter grazing highly undependable until late January to mid-February. This, plus the high cost of presently available winter grazing crops, makes them generally unsuited (except as a supplement) for the cow and calf beef production program.

If the five criteria of dependability, economy, efficiency, safety, and versatility be used to choose forages for the period November 15 to April 15, the choices will generally be: Crop residues and frosted grass where available until January and hay or silage thereafter. Hay and silage can be made from summer-growing grasses that meet these five requirements. Coastal and Suwannee bermudagrasses for hay and Gahi-1 pearl millet for silage will be hard to beat in most of the coastal plain.

Animal aspect - Cow-calf, Feeder Steer, and Dairy - W. B. Anthony

The genetic capability within our better managed dairy herds has been improved to the point where only high producing cows are in the herds. These cows require large amounts of high quality feeds. Unless the quality of roughage can be kept high, it will be necessary for dairy farmers to depend more and more on concentrates for their herds. It is a fact, however, that high quality roughages continue to offer the lowest cost feed for dairy herds, especially when these feeds are properly supplemented. Changing from poor to excellent quality roughage for a well managed dairy herd will usually increase milk production at least 800 pounds per cow. Presently forages that can be used for high producing dairy herds are annual pastures for grazing and corn, sorghum, and legume silages and legume hays. Permanent type, warm season pastures have limited usefulness for high producing dairy herds in the Southeast. Pelleting of grass hays may be developed as a means of making grass hays equal in feeding value to alfalfa hay.

Permanent, warm season pastures represent the chief source of feed for beef herds in the Southeast. Mature beef cows that have an abundance of pasture forage available will gain weight during the spring and summer period and carry a fleshy condition into the winter period. Mature cows that are fat at the end of the summer grazing period can be carried through the winter on grass hay, salt and water. The milk production of beef cows is not greatly affected by the kind of pasture forage that is consumed so long as the pasture is vegetative and furnishes an abundance of feed. Young cows and bred heifers need some protein supplement along with grass hay during the winter feeding period. There is some evidence from current research that sorghum silages may soon be the most economical source of feed for the winter feeding of beef herds in the Southeast. More research is needed to prove that this is so, but certainly it will be more widely used. Year around confined feeding of beef cow herds will be made practical within the near future. Sorghum silage may

be the feed most used in these operations. Alabama research has shown that calves nursing beef cows on winter feed do benefit from small grain and clover pastures when these are provided by a creep. It is very important, however, that plenty of excellent quality spring pasture forage be available to the calves when the winter feeding period ends. In test at the Alabama Station, beef calves creep grazed through the winter made extra gain on the pasture, but they lost most of this when turned with their dams to Coastal bermudagrass pasture.

The feeder steer effectively utilizes forage, but there are very definite limitations on the feeding plans. Much research has shown that it is not usually good business to winter steers after weaning, graze them through a long summer growing season on permanent pastures and finally finish them in dry lot. On southeastern summer pastures yearling steers gain about 200 pounds during the grazing season and carry a utility to low standard finish off grazing. Most successful systems for growing and finishing the feeder steer are those that use much forage, but provide sufficient quality so that the animal makes an average daily gain of 1.7 pounds are more from the time of weaning until it is finished for slaughter. Actually only two feeding systems appear to offer promise. Each of these systems involves a growing period followed by dry lot finishing. The dry lot finishing plan is about the same for both growing plans. The dry lot finishing feed should normally contain about 20 percent of ground hay with the remainder made up of feed grains and protein supplement. The growing plans may be characterized as follows: (1) confined to dry lot and full fed corn silage plus a daily allowance of 3-4 pounds of corn and 1.5 pounds of protein supplement; (2) grazed on small grain-clover pastures with silage and supplement available to substitute for the grazing during periods of insufficient growth. Confined feeding on silage and supplement appears to offer more promise than the small grain grazing plan. With proper management either system can be used effectively for growing feeder steers prior to dry lot finishing. Presently both systems are much superior to dry lot feeding on a fattening feed without a prior growing period.

In summary, only beef herds effectively utilize permanent type, warm season pastures in the Southeast. Dairy herds make effective use of excellent quality forages. The trend in dairy herds is toward confined feeding. Silages, hays, and green chopped forages make up the major portion of the forage needs of dairy herds. Annual grazing crops have some usefulness for dairy cattle. For growing feeder steers, silages and cool season annuals hold much advantage over other forages. Pelleting of grass hays may be developed to the point where these crops could be effectively utilized for dairy cows and feeder steers.

BREEDING AND GENETICS

J. P. Craigmiles, Georgia, Presiding

An appraisal of the success in improving the forage quality of adapted productive forage species:

Sericea lespedeza - E. D. Donnelly

Objectives in the region generally are breeding for increased: quality - (a) palatability, (b) nutritive value; vigor - (a) seedling, (b) total; and disease resistance.

Two new sericea varieties have been released. Gasyn was released by Georgia. It reportedly has less tannin, smaller stems, and more leaves and retains leaves better than Common. Serala was released by Alabama. It has smaller, softer stems, tillers more profusely than Common, and yields as well or better than other varieties.

Work at North Carolina showed low tannin, as in annual lespedeza Beltsville 23-864, was inherited as a simple recessive. This line and fine-stemmed Alabama lines, as well as others, are being used as parent material in breeding programs in Alabama and North Carolina. At North Carolina, superior low tannin segregates (after 2 backcrosses) are being increased.

Work at North Carolina showed that heavier chasmogamous seed produced more vigorous seedlings than the lighter cleistogamous seed.

In Alabama, lines genetically high and low in percentage chasmogamous flowers and seed have been selected. F_1's of low x high lines appeared to resemble the high parent in this respect and the F_2's are being studied.

Many mutant types were found in the X_2 from irradiated seed in Alabama. Among these were dwarfs, large, and prostrate plants.

Dallisgrass - H. W. Bennett

Most dallisgrass breeding work has stressed seed quality rather than forage quality. It has generally been considered that this species produced forage adequate in quality and that with improvements in seed set a substantial contribution would be made. High quality seed has limited the more widespread use of this species and the quality of forage would be of only academic interest without means of propagating the species.

In Louisiana, significant variation has been observed in seed quality between progenies of clones collected from natural stands of dallisgrass. The reproductive mechanism may limit the possibility of improving forage quality as it has with seed. Unusually hirsute, upright, and spreading stem types have been observed. Whether these types differ in forage quality is not known.

Irradiation has been used by Texas and Mississippi workers to increase seed production and change plant type. Yellow-anthered dallisgrass has been selected for decumbent growth habit, fertility, leafiness, and vigor; 5 lines were rated good to excellent in all characteristics. These will be evaluated for forage production and quality. Like lines from irradiated domestic seed in Mississippi will also be evaluated. All these lines set seed in more than 80 percent of the florets. Segregates from species hybrids, selected for the dallis-type of growth but with high (80-90) seed set are also being evaluated.

Ergot has reduced quality in forage. It has been found that with the high seed setting lines, ergot is of little consequence. The seed evidently grows faster than the ergot. Ergot resistance has been transferred from a sexual species to segregates but poor seed production has persisted.

Tests have shown leafier and more forage is produced by thick spacing. Forage from plants spaced 1 inch apart contained 17.5 percent crude protein as compared to 11.5 percent in plants spaced 6-12 inches apart. Average of composited harvests.

The quality of dallisgrass grown in association with legumes is increased. One dallisgrass plant grown with 2 white clover plants produced as much as 3 grass plants grown alone. It was found that the crude protein of the grass plant grown in association was higher than that of the grass when grown with other grass.

It is felt by the workers with this species that when seed quality is raised more attention can be given to more precise studies with forage quality.

Bermudagrass - Glenn W. Burton

For the purpose of this discussion, "quality" shall be defined as those characteristics of a forage that influence animal performance when quantity is not a limiting factor. To improve quality through breeding, therefore, would be to so change a forage genetically that animals consuming it would give improved performance when quantity is not limiting.

There is some evidence that Coastal bermudagrass is superior to common bermuda in quality. Daily gains of steers on Coastal bermuda have been better than those on common bermuda in several experiments. In other tests, no difference has been observed.

Research has shown that grass leaves with diseased tissue are lower in protein and other nutrients than those free of disease. Thus, increasing the disease resistance of a forage should automatically improve its quality, and this has been done in Coastal bermuda.

It is believed that those other intangible characteristics that influence quality could be improved by breeding if they could be characterized and measured. With a suitable forage quality test, the forage breeder should be able to improve forage quality through breeding. Such a test should (1) require only a few grams of forage, (2) be inexpensive, (3) be rapid, (4) be precise, (5) be repeatable, and (6) give results that correlate well with large animal performance. The remainder

of this report will deal with efforts to develop such a test.

Table 1 shows that lignin content is inversely correlated with digestibility, and digestibility and intake have been said to determine animal performance. A lignin analysis of forage samples might be used to select for improved quality.

Table 1. Effect of age on the lignin content and digestibility of Coastal bermudagrass by sheep.

Age	Lignin content %	Digestibility %
2 weeks	9.5	70.9
3 weeks	9.7	70.4
4 weeks	10.3	65.7
6 weeks	11.2	66.5
8 weeks	12.1	59.1

In 1959, cooperative studies were begun with E. W. Beck, ARS entomologist at Tifton, Georgia, to explore the possible use of the armyworm as a small test animal to measure forage quality. The gains made by worms weighed on and off several forages shown in Table 2 agree reasonably well with observations on cattle performance on these grasses. Table 3 shows that eight feeding experiments with armyworms have given fair to good precision. Significant differences in armyworm performance on different bermudagrass genotypes have been obtained (Table 4). Correlations between armyworm and cow performance must be established, however, before such a test can be used with confidence. One weakness of this test lies in the fact that armyworms eat only the leaf blades, whereas cattle eat both leaves and stems.

Table 2. Effect of species on armyworm gains, August 28-September 4, 1959.

Grass	Mgm. Gain
Centipede	23
Common bahia (old)	60
Pensacola bahia (old)	102
Pensacola bahia (young)	235
Coastal bermuda	283
5% LSD	85
CV	33%

Table 3. C.V.'s of armyworm forage quality experiments conducted at Tifton, Georgia.

Experiment	Weight gain	Times weight increase
3	30%	19%
4	42	36
5	15	18
6	13	5
7	15	18
8	8	8
9	16	13
10	22	11
Ave.	16	13

Table 4. Effect of bermudagrass genotype on armyworm gains.

Selection number	Times weight increase
7	5.2
29	3.3
30	2.4
38	3.8
53	4.9
5% LSD	.8
CV	7.6%

An *in vivo* "digestibility" test developed by D. W. Beardsley at Tifton, Georgia, has given very precise results and offers much promise. The test consists of a quantitative measure of the disappearance of 10 grams of ground dry matter from small nylon bags placed in the fistulated rumen of steers for varying periods of time, usually 72 hours. Statistical analyses of data from several tests reveal that duplicate samples in the rumen respond similarly. The CV's for most such experiments

have been less than 5%. Tables 5 and 6 show some of the results obtained when uniformly fertilized 4-week-old samples of 21 bermudagrass genotypes were "digested" in two steers for 72 hours. If animal performance will correlate with tests of this kind, the plant breeder will have a practical test that can be used to screen many spaced plants for quality.

Table 5. *In vivo* "digestibility" of bermudagrass hybrids.

Source	DF	MS
Steers	1	.58
Strains	20	55.41**
Steers x strain	20	2.48**
Error	42	.99

** Significant at the 1% probability level

Table 6. *In vivo* "digestibility" of bermudagrass hybrids (4 weeks old, Sept. 10, 1962)

Hybrid or variety	"Digestibility"
Common	59.6%
Coastal	59.0
Coastal x Kenya No. 9	47.9
Coastal x Kenya No. 11	52.4
Coastal x Kenya No. 14	60.9
5% LSD	1.8
CV	1.8%

Tall fescue - J. P. Craigmiles

Forage quality can be defined as the relative ability of a plant to meet an animal's nutrient requirment when fed free choice. Forage quality is easy to define but difficult to change.

One of the constituents of quality is palatability. Palatability is a complex phenomenon determined by both the livestock and the forage offered. It is usually thought of as the percentage of the plant consumed under proper grazing conditions. Even though palatability and appetite are often confused appetite appears to be the factor of major importance in nutritive value.

Categorically, tall fescue is a low quality forage plant but indications are that this can be improved. This discussion on the improvement of forage quality in fescue will be concerned primarily with results obtained in Georgia on the effect of plant characteristics on palatability or animal selectivity.

In 1953, ninety genotypes of tall fescue based on leaf type, growth type, and animal selectivity were removed from a space planted nursery of approximately 30,000 plants of wide genetic base. These clones were increased vegetatively, broken into propagules and established in a randomized polycross nursery replicated 12 times. The nursery was grazed after the plants had become well established and notes on leaf type, plant type, disease, maturity and grazing intensity were made.

After grazing, seed were harvested from the wide base polycross and planted in a paired plot grazing trial, each plot being 3' x 20'. Prior to grazing, one of each paired plot was clipped and the dry matter determined. Immediately after grazing the plots were again clipped. The amount of forage consumed from each plot was then determined as the difference between the before grazing and the after grazing dry weights.

A significant correlation (r = .241) was found to exist between the palatability of the clone and the palatability of progeny of the clone. This correlation between clonal grazing and plot grazing indicates palatability is heritable.

There was a significant correlation (r = .476) between broadness or coarseness of leaf (broad leaf versus fine leaf) and palatability in both clonal and polycross progeny grazing trials.

A correlation (r = .051) could not be established between clone type (upright growth versus procumbent growth) and palatability. Correlation (r = .014) between leaf type and clone type could not be determined.

Although conspicious exceptions were consistently found, results indicate that differences in palatability are due to differences in mechanical or physical texture of the plant rather than to variations in taste or nutritive value. Broad, thick, coarse leaf plants were more palatable than narrow, thin, fine leaf plants. Animal preference for plant growth type could not be established.

C. R. Owen, Louisiana, Presiding

An appraisal of the success in adapting high quality perennial forage species to the Atlantic and Gulf Coast states:

Orchardgrass - L. H. Taylor

The orchardgrass acreage for 1962 and for the average of the previous five years for the United States and the regions thereof are given in Table 1. Orchardgrass is of some importance in all regions, with the greatest acreage being grown in the Southern and North Central Regions. For the United States, the 1962 acreage is some 14% greater than the five year average. Most of the increase has occurred in the North Central Region with the Southern and Western Regions showing very little increase in acreage. For the U. S. as a whole, the percentage of the total acreage planted to named varieties has declined slightly. This, and the marked fluctuations in this regard in most of the regions, is largely due to the increase of acreage of S-37 and decrease in acreage of S-143 in certain states.

Table 1. Orchardgrass Acreage in U. S. and by Regions

	1,000 Acres		1962 A. as a % of	Named Varieties % of Acreage	
	1957-61x	1962	1957-61x	1957-61x	1962
United States	4,737.9	5,413.9	114.3	14.4	12.0
North Eastern Region	402.6	477.5	118.6	17.2	30.7
North Central Region	1,323.0	1,867.6	141.2	4.4	8.9
Southern Region	1,761.0	1,802.0	102.3	4.6	1.5
Western Region	1,251.4	1,266.8	101.2	38.0	24.6

We will now consider in more detail just where orchardgrass is grown in the United States. In Table 2, all of the states that grow 100,000 or more acres of orchardgrass are listed in order of their reported acreage. (West Virginia, which is not listed, is estimated by its extension agronomist to have 300,000 acres of orchardgrass with 2-3% of this planted to named varieties.) In the West, most of the orchardgrass is grown in the Pacific Coast states. As the Western Region is somewhat remote from the rest of the orchardgrass area with quite different conditions and problems, it will be largely ignored in the rest of this report. In the North Central and North Eastern Regions, most of the orchardgrass is grown in the more southerly states while in the Southern Region the orchardgrass acreage is found in the more northerly states.

Table 2. Leading States in Orchardgrass Production - 1962 Data

Rank	State	1,000 Acres	Named Varieties % of Acreage
1	Virginia	751.	.13
2	Iowa	610.	1.6
3	California	591.	15.4
4	Ohio	550.	27.3
5	North Carolina	430	4.7
6	Missouri	343.5	1.0
7	Tennessee	265.5	.56
8	Illinois	222.0	.90
9	Washington	215.0	76.7
10	Kentucky	168.5	.89
11	Pennsylvania	150.0	56.7
12	Maryland	127.0	4.7
13	Arkansas	122.5	2.0
14	Oregon	112.0	33.0
15	Utah	103.3	.29
16	New Jersey	100.0	28.0
16	Colorado	100.0	0

The question arises as to whether we are dealing with a Northern species grown in the South or a Southern species which is also grown in the North. A more critical examination of the data provides some clarification on this point. In the area of the United States east of the Great Plains, the only states with a considerable acreage of orchardgrass that lie entirely north of the Mason-Dixon line are Iowa and Pennsylvania; all other states with substantial orchardgrass acreages lie either entirely or in part south of this line. The historical significance is obvious. Orchardgrass is predominantly a southern species. An examination of the states in which orchardgrass is an important component of the total forage production confirms this conclusion. Of the states where it is estimated that 10% or more of the forage acreage is planted to orchardgrass only one - Iowa - lies north of the Mason-Dixon line, two - Ohio and New Jersey - are largely north of the line, three - Delaware (which estimates that 75% of its forage acreage is planted to

orchardgrass), West Virginia and Missouri - are largely south of the line and four - Virginia, North Carolina, Tennessee, and Kentucky - are south of the line.

The percentage of the orchardgrass acreage planted to named varieties for the states listed in Table 2 is extremely variable. However, in only two of these states - Washington and Oregon - is more than 10% of the orchardgrass acreage planted to improved varieties developed in breeding programs in the United States. Data on orchardgrass varieties for the United States as a whole are given in Table 3. Common and Danish ecotypes represent 88% of the United States acreage. Named varieties that have

Table 3. Orchardgrass Acreage by Varieties, Expected Trends - U. S. Acreage

Variety	1957-61x 1000 Acres	1962 1000 Acres	1962 % of Total Acreage	Expected Trend 1/
Common	3,769.4	4,400.2	81.3	1.0
Danish	282.8	361.0	6.7	1.0
S-37	92.6	240.5	4.4	1.0
Akaroa	192.2	151.0	2.8	1.1
Potomac	110.1	113.7	2.1	1.0
Latar	38.3	69.8	1.3	1.1
Pennlate	25.0	40.5	.7	1.1
S-143	225.5	25.0	.5	0.9
Mass-Hardy	---	2.1	---	1.2
Ky. Select	2.0	2.0	---	1.0
Sandia	---	2.0	---	1.1
All Others	---	2.0	---	---
Late Finnish	---	1.6	---	1.0
Sterling	---	1.5	---	1.1
Boone	---	1.0	---	1.2

1/ 1.2 - moderate increase
1.1 - slight increase
1.0 - stationary
0.9 - slight decrease

been imported such as Akaroa and S-37 are next in importance. The improved varieties that have come from breeding programs in the United States - Potomac, Latar, Pennlate, Mass-Hardy, Sandia, Sterling, and Boone - are reported as being grown on 173,400 acres in 1957-61 and 230,600 acres in 1962. This represents 3.7% and 4.3% of the United States acreage. The expected trends indicate that for most varieties the acreage will remain stationary or show only a slight increase. Expected trends for the Southern Region are for a sharp increase in Boone, a slight increase in Potomac, for the acreage of Common and Kentucky Select to remain stationary and that of Danish to show a slight decrease. I am inclined to agree with the trends as reported. No variety of orchardgrass currently available seems likely to be widely enough used to occupy any substantial proportion of the orchardgrass acreage in the United States or the Southern Region.

Let us now pause and look at what our friends, the extension agronomists, think about orchardgrass.

North Eastern Region

As to potential -- preferable to seed canary and brome (Mass.)...orchardgrass is very well adapted, its future is bright (W.Va.)...the best grass presently available for use (Del.)...as new late heading varieties come along, its use will increase (Pa.) ...potential use is good but educational job needs to be done on management (N.J.).

As to problems--management of stands (Md.)...grazing or cutting at too late a stage of maturity (W.Va.)...overgrazing, especially under high nitrogen fertilization (Del.)...lack of proper grazing and clipping management early in the season (N.J.)... difficulty farmers experience in early harvest and lack of palatability due to late harvest (Mass.)...failure to use sufficient nitrogen (Mass.)...lack of proper fertilization practices (Md.)...matures before most of our farmers are ready to make the first harvest (N.Y.)...not equipped to utilize the heavy spring growth most efficiently (Del.)...matures too early for alfalfa (W.Va.)...Mass-Hardy, the superior variety here, is not being increased by seed companies (Mass.)...winter killing with S-37 (Pa.)...lack of winter hardiness, particularly in some of the named varieties (Conn.)

North Central Region

As to potential--its about the only forage crop now showing a consistent upward trend (Ill.)...expect a material increase of acreage seeded with alfalfa (Mo.)... orchardgrass acreage will continue to increase at the expense of Timothy (Ia.)... expect some increased use in irrigated pasture mixtures (Neb.)...is the best grass under a 3 cut system with alfalfa (Wisc.)...use where brome is killed under a 3 cutting system (Mich.)...if a good, high-yielding, late maturing variety becomes easily available, we would probably double O.G. usage (Ill.).

As to problems--(General)...need better management for maximum production or pasture (Ia.)...worst problem - matures too early (Ill.)...lack of palatability as it approaches maturity (Mich.)...lack of fertilizer, especially N & K, and grazing management (Ind.)...has to be cut early for quality hay (Ia.)...lack of drought resistance and comparatively short life (Mo.)...some leaf disease problems (Ia.)... leaf diseases in summer (Ind.)...brome fits situations in state better than orchard (Mich.).

(Fringe)...orchard not as good as brome (Kan.)...rainfall insufficient in most areas (Neb.)...early maturity and winter killing (Wisc.)...winter - injury (Minn.)...winter-killing (S.Dak.)...lacks winterhardiness (Neb.).

Southern Region

As to potential--No. 1 grass for the dairy farmer (Ark.)...it is our best quality, cool season, perennial grass (Ala.)...excellent (in the absence of a more desirable tall grass) (Va.)...will increase with a better adapted variety (N.C.).

As to problems--lack of interest on the part of farmers to manage the plant as a crop (Ky.)...overgrazing and grazing during hot summer months (Tenn.)...early maturity of spring growth with accompanying loss of quality (Va.)...peak periods of production (Ky.)...need more vigor in pure stands with high N. (N.C.)...poor fertilization; low rates and infrequent application (Tenn.)...lack of persistence (Va.)... beef cattle farmers are changing to fescue because it will withstand more adverse weather conditions and mismanagement (Ark.)...difficult to maintain stand in clover-grass permanent pasture (Ala.)...poorly adapted to eastern piedmont and in coastal plain (N.C.)...not adapted (Fla.)...excessive heat prevents use (Texas)...hot weather arrives too early (Miss.)...disease problems (Ga.)...need more disease resistance (N.C.)...susceptible to diseases (Ala.).

In summary, the workers in these three regions see orchardgrass as having considerable potential and many problems. All regions see many management problems and a need for improved varieties. The North Central and North Eastern Regions are concerned about winterhardiness and are apparently more concerned with early maturity than the Southern Region. There is more concern with adaptation to hot summers and with diseases in the Southern Region.

There was an indication in the survey of extension agronomists in states growing orchardgrass that they expected an increase in the usage of named varieties. In the North Eastern Region, 7 or 8 expected this, in the North Central Region 6 or 7 and in the Southern Region 6 of 7. If I am correct in assuming that present varieties have little potential, especially for the South, perhaps we should consider the problem of developing improved varieties so that the faith our extension friends have in us may prove justified.

But first, what is this common orchardgrass that is grown on more than 80% of the orchardgrass acreage in the United States and in the South? It is an ecotype, or a group of ecotypes, seed of which is produced within an area 150 miles south of the Mason-Dixon line aforementioned. Almost all of the orchardgrass grown in the United States east of the Great Plains is grown in areas within 300 miles north or south of the districts in Virginia, Kentucky, and Missouri where the bulk of the seed of common orchardgrass is produced. There is probably a good reason for this. For this is an "uncommon" orchardgrass too, selected by nature for adaptation to the areas of seed production and to environments not too unlike these. Man and nature have selected it for seed production; naturally it tries to produce stems. It is full of genetic homeostosis for persistence, early maturity and other things, not all of which we want. But there are enough characters of value that we do not find it an easy job to produce something better. Can we expect improved varieties developed North of the areas of

present seed production to be of much value to us in the South? I doubt it.

So we must develop our own varieties. I wish I could tell you how, but that is a problem for which at present we have ideas rather than answers. I would suggest that there are two separate problems: 1) to change toward a more desirable type in the areas where orchardgrass is reasonably well adapted and 2) to develop types that will persist and produce in areas in which orchardgrass is not well adapted. For this second problem we might let natural selection give us a hand. Any of us working in orchardgrass breeding in the South could do this, for orchardgrass is not well adapted to all parts of any Southern state.

In conclusion I will mention two additional thoughts. First, the cooperation now existing in exchange of materials and ideas between the orchardgrass breeders in Arkansas, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia could serve a useful purpose in extending the area in which orchardgrass can contribute to the forage program. Second, a word of caution. We cannot afford to sacrifice strength, the qualities that make a species of forage value, in order to correct any specific weakness. This is as true of orchardgrass as of any other species.

<u>Alfalfa</u> - E. S. Horner et al.

According to replies received to a questionnaire, active breeding work on alfalfa is being carried on in only four southeastern coastal states: Virginia, North Carolina, Florida, and Mississippi. Breeding objectives vary from state to state, but all breeders are concerned with persistence (associated with diseases) as a major objective.

Virginia (T. J. Smith) has a number of clonal lines under test which have excellent potential with respect to seedling vigor, rapid recovery after cutting, persistence, yield, and quality. The variety Williamsburg was developed by mass selection from Kansas Common at Williamsburg, Virginia. It appears to have greater resistance than the parental variety to crown rotting organisms in the Coastal Plains of Virginia and North Carolina and it recovers more quickly after cutting (N.C. A.E.S. Bul. 421).

In North Carolina and Florida the major problem in adaptation is summer persistence. The North Caorlina work has resulted in the development and release of Cherokee, which in the fifth harvest year was maintaining stands better than Atlantic or Williamsburg, the two most widely used varieties in the State. Yields in the fifth year were 25-30 percent above the average of Atlantic and Williamsburg. Additional progress in North Carolina is indicated by the fact that a Cherokee type stem nematode-resistant synthetic will be increased for testing in 1964 and a Flemish type resistant synthetic is currently being increased.

Work in Florida has been devoted primarily to summer persistence and secondarily to seed production. A mass selection scheme similar to that used to develop Williamsburg is being followed. Definite progress has been made in improving summer persistence without reduction of yields during the winter and spring seasons. Plant counts show that about twice as many plants per unit area survived the 1962 summer in the plots of the selected strain as in plots of the best commercially available varieties. Since the results of this work have been encouraging this system of adapting alfalfa to Florida is being expanded.

Work in Mississippi by H. W. Johnson has resulted in the development of Stoneville P.C. 1, which is superior in that area from a disease resistance and yield standpoint. This variety has not yet been released.

In summary, definite progress is being made toward adapting alfalfa to the Atlantic and Gulf Coast States. The problems appear more acute in the far south coastal plain area, including Florida, than in the coastal plains of North Carolina and Virginia and in the piedmont and mountain areas of the Coastal States. However, the results of the rather small amount of work done to date in the whole area are very encouraging. More progress can be expected in the future.

White clover - W. C. Johnson et al.

Alabama - Lack of persistence is the major weakness of white clover in Alabama and the Southeast in general. The factors which are responsible for this lack of persistence are not clearly defined. Major emphasis at present is on the role of root-knot nematodes in persistence and screening material for resistance. To date no clear-cut resistance has been found. However, several selections for apparent tolerance have been made.

Field evaluations for persistence are made on space-planted ladino. Selections of superior clones from this type material have been made. A synthetic variety of 5 clones selected in this manner has been released (named Regal). Seed is being produced in California and will be available for farm use in the fall of 1964.

Four cycles of recurrent selection have been completed on an intermediate or profuse flowering type population. Selections from the last cycle of this material are being grown under isolation to produce seed for testing. Bulk seed of the 3rd and 4th cycle have been grown for observation in pastures.

Florida - The main objective has been to obtain better summer persistence. Individual plants and clones have been selected for ability to survive the summer over a period of years. A 12-clone synthetic developed at Gainesville is now being evaluated. Preliminary observations in 1962 indicate that this synthetic is superior to La. S-1 and Nolin's La. white clover in persistence.

Louisiana - The objective for white clover improvement in Louisiana has been to develop better adapted strains of white clover for Louisiana and the South. It was proposed in the beginning that germinal material present in acclimated white clover be surveyed and that the more desirable types be utilized in the formation of improved strains, varieties or types.

With persistence through the summer months as the principal criterion, clonal lines were isolated, evaluated for general combining ability and finally certain of the superior clones were combined into experimental synthetic varieties. Louisiana S1 white clover was developed from clonal lines isolated in the first cycle. This variety has since been used over wide areas of Louisiana, in certain regions of Texas and Mississippi and to a less extent in other Southeastern states.

It has contributed by extending the season for the utilization of white clover in pastures in the Gulf States. Along with better management practices the improved variety has added substantially to the value of white clover as a pasture crop. Its general use has been limited because of short seed supplies.

South Carolina - Most of the progress has been in the field of defining the weaknesses of white clover. We have determined that white clover is susceptible to each of the species of root-knot nematodes known to be present in America. Also, we have determined that a number of soil-borne pathogenic fungi in a sand inoculum prevent rooting and cause the death of stolon cuttings placed therein. Defining the weaknesses of white clover involves consideration of the pathogen, the environment and the physiology of the host.

The purpose of studying the weaknesses is to provide the essential fundamental information needed for developing screening techniques which may be used to identify superior germ plasm. We consider that we have a satisfactory technique of screening for plants that are superior in performance in the presence of root-knot nematodes and we are optimistic concerning techniques of screening for resistance to soil-borne pathogenic fungi.

The status of quantitative inheritance studies in forages - J. W. Dudley

Quantitative inheritance studies may be defined as studies aimed at elucidating the type of gene action controlling a character for which inheritance cannot be explained on a simple Mendelian basis. Such studies include estimation of genetic variances, comparisons of progeny means (F_1, F_2, Parents, etc.), and evaluation of response to varying types of selection.

Quantitative inheritance studies are usually designed to answer one or more of the following questions:

a. Is genetic variance present for the characters of interest in a particular population?
b. What proportion of the phenotypic variance is genetic?
c. What proportion of the genetic variance is additive, dominant, or epistatic?
d. What type of selection program will be most effective?
e. Given a particular selection program, how much response can be expected?
f. What kind of variety (i.e., F_1 hybrid, advanced generation synthetic, pure line, etc.) should be the end product of the selection program?

Many different kinds of designs have been developed for studying quantitative inheritance. The choice of design for a particular study depends on the mode of reproduction of the organism, on the objectives of the study, and to a certain extent on the ploidy level and type of ploidy of the organism.

As might be expected with the varying modes of reproduction and varying ease of vegetative propagation of forage crops a number of different types of studies have been made. In most species an attempt has been made to estimate the total genetic variance in relation to the phenotypic variance. In some studies the population included as many different collections of the species from all over the world as the investigator could obtain (Carlson and Moll, 1962), in others the collections represented a sample of a particular region of interest (Eberhart and Newell, 1959), in others, a particular variety of a cross-pollinated species (Kehr and Gardner, 1960), while in others the entries were simply a group of selected clones (Burton and DeVane, 1953). In nearly all cases a significant amount of genetic variance was found for most characters; and heritability values, at least on a plot mean basis, were relatively high (50% or greater). Thus for many forage species questions a and b have

been partially answered.

Question c and succeeding questions are not so easily answered. In several forage species attempts have been made to determine whether the proportion of the phenotypic variance which is additive (narrow sense heritability) or the proportion of the total genetic variance which is additive. No report of a serious attempt to separate the dominant and epistatic types of variance in a forage species was found in the literature. One reason for this has been the necessity of having a number of different types of progenies from one population for separating the types of genetic variance. Another reason for lack of information on relative proportions of different types of genetic variance may be the lack of a clear cut idea of how to alter a breeding program if epistasis is more important than dominance or vice versa.

The results of some of the attempts to determine the proportions of additive and non-additive variance are of interest. Kehr and Gardner, 1960, in an extensive study of yield in Ranger alfalfa found that 33 percent of the genetic variance was of the additive type and concluded that reciprocal recurrent selection might be an effective breeding procedure. Burton, 1959, studying yield of pearl millet found an average of 44 percent of the genetic variation was additive although with different groups of inbreds this percentage varied considerably. He concluded that a hybrid program should be most effective in this species. Newell and Eberhart, 1961, working with switchgrass found the additive variance to be 30 to 90 percent of the total genetic variance depending on the character studied. They concluded that development of synthetic varieties should be a suitable method of improvement.

In nearly all the quantitative inheritance studies to date the assumption was made that the species behaved as a diploid at meiosis and only occasionally the fact that the species might be a polyploid was mentioned. If a polyploid species behaves as an alloploid or as an amphidiploid, diploid theory is adequate. If the species behaves as an autoploid, diploid theory is not adequate. Recent work by Levings and Dudley, 1963, has clarified the problems involved in studying quantitative inheritance in autotetraploids. In their work the model proposed by Kempthorne (1955) for autotetraploids was used. The common diploid genetic model is contrasted with the tetraploid model in table 1. The unique features of the autotetraploid model are the presence of trigenic (σ_T^2) and quadrigenic (σ_F^2) variances arising from interactions between three and four alleles at a locus, respectively.

Table 1. Diploid and autotetraploid genetic models

Ploidy	Model
2n	$\sigma_G^2 = \sigma_A^2 + \sigma_D^2 + \sigma_{AA}^2 + \sigma_{AD}^2 + \sigma_{DD}^2$, etc.
4n	$\sigma_G^2 = \sigma_A^2 + \sigma_D^2 + \sigma_T^2 + \sigma_F^2 + \sigma_{AA}^2 + \sigma_{AD}^2 + \sigma_{AT}^2$, etc.

If twice the parent offspring regression is considered as the best estimate of narrow sense heritability, the variance components included in the estimate of heritability in the autotetraploid case will differ from the diploid case as shown in table 2.

Table 2. Genetic components of variance included in narrow sense heritability estimates in diploids and autotetraploids.

Ploidy	2 Regression PO = narrow sense heritability
2n	$\dfrac{\sigma_A^2 + \frac{1}{2}\sigma_{AA}^2, \text{ etc.}}{\sigma_P^2 = \text{phenotypic variance}}$
4n	$\dfrac{\sigma_A^2 + \frac{1}{3}\sigma_D^2 + \frac{1}{2}\sigma_{AA}^2 + \frac{1}{6}\sigma_{AD}^2 + \frac{1}{18}\sigma_{DD}^2, \text{ etc.}}{\sigma_P^2}$

Thus in autotetraploids where two alleles per locus are transmitted some dominance variance is included in the narrow sense heritability estimate.

To estimate the magnitude and importance of various types of genetic variance in autotetraploids an estimation procedure has been devised which will permit estimation of the four intra-locus components (σ_A^2, σ_D^2, σ_T^2, σ_F^2); or if σ_T^2 and σ_F^2 are considered unimportant, σ_A^2, σ_D^2, σ_{AA}^2, and σ_{AD}^2 can be estimated. The estimation procedure utilizes a replicated planting of the parent clones in conjunction with a partial diallel among the parental clones. From these plantings total genetic variance (σ_C^2) can be estimated (from analysis of variance of the parental clones), a parent offspring covariance can be obtained σ_{PD} and estimates of general and specific combining ability (σ_G^2 and σ_S^2) can be made (from the partial diallel). Coefficients of the components of genetic variance for a diploid analysis are shown in table 3 and for the autotetraploid analysis in table 4.

Table 3. Coefficients of components of genetic variance from the proposed estimation procedure (Diploid model)

Variance or covariance component	Genetic variance component σ_A^2	σ_D^2	σ_{AA}^2	σ_{AD}^2
σ_g^2	$\frac{1}{4}$	0	$\frac{1}{16}$	0
σ_a^2	0	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{8}$
σ_{po}	$\frac{1}{2}$	0	$\frac{1}{4}$	0
σ_c^2	1	1	1	1

Table 4. Coefficients of components of genetic variance from the proposed estimation procedure (Autotetraploid model)

Variance or covariance component	Genetic variance component					
	σ^2_A	σ^2_D	σ^2_T	σ^2_F	σ^2_{AA}	σ^2_{AD}
σ_g^2	$\frac{1}{4}$	$\frac{1}{36}$	0	0	$\frac{1}{16}$	$\frac{1}{144}$
σ^2_s	0	$\frac{1}{6}$	$\frac{1}{12}$	$\frac{1}{36}$	$\frac{1}{8}$	$\frac{7}{72}$
σ_{po}	$\frac{1}{2}$	$\frac{1}{6}$	0	0	$\frac{1}{4}$	$\frac{1}{12}$
σ^2_c	1	1	1	1	1	1

Use of the partial diallel allows a more adequate sampling of the parent population. In alfalfa a sample of 100 clones each crossed with 4 others is proposed. With the ease of vegetative propagation of most of the cross pollinated forages this estimation procedure should be applicable to a number of different species.

Summary

In most forage species some estimate of the total genetic variation relative to the phenotypic variance is available. In a few species the total genetic variance has been divided into additive and non-additive portions. No attempt has been made to separate dominance from epistatic variance. An estimation procedure which allows estimation of genetic variance components in autotetraploids is presented.

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Techniques for Evaluating Breeding Lines, Polycrosses, and Other Test Crosses in a Breeding Program with Emphasis on Economy - M. S. Offutt

Research, at best, is costly, and it is becoming more so as time goes on. Two main factors would appear to contribute materially to this situation. First, the easy and less costly research has already been accomplished, for the most part, in the field of plant breeding. The rate at which further progress is made is almost certain to be slower and more difficult than in the past. Additional equipment of special design and of a highly complicated nature will be required. This kind of equipment is expensive, and all indications are that costs of such specialized equipment will go still higher. Secondly, labor costs have spiraled upward as a result of nation-wide wage rate increases. In the future a higher proportion of labor with technical training will be required to operate the specialized equipment called for in future research. This can be expected to increase the cost of research still further. Substantial increases in research funds will be required just to maintain our plant breeding efforts at their present level.

Project maintenance funds in Arkansas have been rather limited in the past, and there does not appear to be much hope for substantial increases in the foreseeable future. It is imperative, therefore, that techniques which emphasize economy be developed and utilized to the fullest, if a reasonable rate of progress in plant breeding is to be expected in the future. A few of the techniques that have been developed and that are being utilized in the legume breeding programs will serve to illustrate the emphasis that is being placed on obtaining the most information per dollar expended for research in Arkansas.

Polycross vs. S_1 Progenies for Estimating the Combining Ability of Parental Clones of Alfalfa-Eighteen creeping, pasture-type clones were established in a space-planted polycross nursery at Fayetteville in the spring of 1957. A randomized block design with 10 replications was used for the study. Selfed$_1$ (S_1) seed was obtained by selfing the floweres on approximately 5 racemes per plant. Polycross (P.C.) seed was obtained by allowing the flowers on the remaining racemes to cross-pollinate at random by natural means.

A progeny test, which included the parental clones and their S_1 and P.C. progenies, was established at Fayetteville in the spring of 1958. Field plots for this test were arranged in a split-plot design and replicated 5 times, with clones as main plots and parents, S_1 progenies, and polycross progenies as subplots. The subplots were composed of 5 plants spaced 3 feet apart in a single row. Subplot rows also were spaced 3 feet apart. Parents, S progenies, and P.C. progenies were evaluated for forage yield, creeping habit, percent leaves, and rate of recovery after cutting in 1959 and 1960.

Two 6-clone synthetics were synthesized from the original 18 clones, one based on data from the P.C. progenies (Ark. Syn. P-1) and the second based on data from the S_1 progenies (Ark. Syn. P-2).

Data on forage yield, percent of plants creeping, percent leaves, and rate of recovery after cutting of the 6 parental clones and their P.C. progenies of clones selected as parental lines for Ark. Syn. P-1 on the basis of their P.C. progeny performance are presented in Table 1. Comparable data for the parental clones and their S_1 progenies of the 6 clones selected as parental lines for Ark. Syn. P-2 on the basis of their S_1 progeny performance are presented in Table 2. As was expected, the S_1 progenies averaged lower in forage yield and in percentage of creeping plants at the end of both the first and second years than the P.C. progenies relative to the parental lines. There was little difference, however, between the S_1 and P.C. progenies for percent leaves and rate of recovery after cutting relative to the parental clones. It is of interest to note that of the 6 clones selected as parental lines for a synthetic variety on the basis of their P.C. progeny performance, 3 of the same clones also were selected as parental lines for a 6-clone synthetic variety on the basis of their S_1 progeny performance.

Rooted cuttings of the 6 clones included in each of the 2 synthetics were established at Fayetteville in 1960 in separate blocks that were isolated at least one-fourth mile from each other and from all other alfalfa plantings. A randomized block design with 26 replications was used for each of the 2 seed increase blocks. Plants within each of the blocks were allowed to cross-pollinate at random by natural means, and the seed produced on each plant was harvested separately. Parental clones used for the synthesis of Ark. Syn. P-1 (clones selected on basis of their P.C. progeny performance) yielded an average of 8.90 grams of seed per plant, and those used in the synthesis of Ark. Syn. P-2 (clones selected on the basis of their S_1 progeny performance) yielded an average of 7.76 grams of seed per plant.

Equal amounts of seed from each parental line was composited and mixed thoroughly for each of the 6-clone synthetics. The composited synthetic-1 seed from each of the two 6-clone synthetics was used to establish synthetic-2 seed increase blocks at 2 locations, Fayetteville, Arkansas in the spring of 1961 and Fresno, California in the spring of 1962. Synthetic-2 seed yields were very low at Fayetteville (distance isolation) in 1961 and again in 1962, due to extremely unfavorable climatic conditions, but seed yields were reasonably high at Fresno (cage isolation) in 1962. At the California location, Ark. Syn. P-2 produced 44.0% more seed per cage than Ark. Syn. P-1.

A part of the Synthetic-2 seed which was produced at Fayetteville in 1961 was used to establish a yield trial at Fayetteville in the fall of 1961. The 1962 results from this yield trial are shown in Table 3. Although differences were not statistically significant, Ark. Syn. P-2 was slightly superior to Ark. Syn. P-1 in performance for all characters studied except percent leaves and rate of recovery after cutting. Further testing will be necessary, however, before definite conclusions can be reached.

Table 1. Forage yield, percent of plants creeping, percent leaves, and rate of recovery after cutting of parental clones and their P.C. progenies of clones selected as parental lines for a 6-clone synthetic on the basis of their P.C. progeny performance.

Clone	Plant Material Class	Forage yield in lbs. of green wt. per 5-plant plot for 3 years	Percent of plants creeping: At end of 1 year	Percent of plants creeping: At end of 2 years	Percent leaves 2-year ave.	Recovery after cutting[1/]
C-501	Parent	25.02	90.0	100.0	56.3	6.9
	P. C. Progeny	32.16	71.4	90.0	56.5	6.3
C-502	Parent	45.32	50.0	75.0	53.2	6.8
	P. C. Progeny	32.12	44.4	71.0	56.3	6.9
C-505	Parent	48.14	93.8	100.0	51.5	5.3
	P. C. Progeny	28.12	54.5	55.0	60.3	6.7
C-508	Parent	37.40	81.0	65.0	55.2	7.0
	P. C. Progeny	36.50	56.3	67.0	58.7	6.8
C-511	Parent	24.82	90.1	86.0	57.9	7.7
	P. C. Progeny	30.70	36.8	38.0	58.4	7.0
C-512	Parent	43.96	82.6	96.0	60.6	7.0
	P. C. Progeny	38.48	61.9	90.0	59.3	7.1
Ave of Buffalo, Rambler, and Rhizoma		51.96	13.9	24.7	51.7	4.8
Ave. of parents		37.44	81.3	87.0	55.8	6.8
Ave. of P. C. progenies		33.01	54.2	68.5	58.5	6.8
Ave. diff. between parents and P. C. progenies		-11.8%	-33.3%	-21.3%	+ 4.5%	0.0%

1/ Recovery after cutting scores based on scale of 1 to 9; 1 = rapid recovery, 9 = slow recovery.

Table 2. Forage yield, percent of plants creeping, percent leaves, and rate of recovery after cutting of parental clones and their S_1 progenies of clones selected as parental lines for a 6-clone synthetic on the basis of their S_1 progeny performance.

Clone	Plant Material Class	Forage yield in lbs. of green wt. per 5-plant plot for 3 years	Percent of plants creeping: At end of 1 year	Percent of plants creeping: At end of 2 years	Percent leaves 2-year ave.	Recovery after cutting 1/
C-501	Parent	25.02	90.0	100.0	56.3	6.9
	S_1 Progeny	33.68	52.9	87.0	57.6	6.6
C-504	Parent	48.66	80.0	100.0	59.2	6.4
	S_1 Progeny	26.52	36.8	50.0	58.3	7.0
C-509	Parent	2/	2/	2/	2/	2/
	S_1 Progeny	40.46	60.0	75.0	52.0	6.9
C-511	Parent	24.82	90.1	86.0	57.9	7.7
	S_1 Progeny	14.02	53.8	60.0	61.7	8.3
C-512	Parent	43.96	82.6	96.0	60.6	7.0
	S_1 Progeny	21.46	8.7	35.0	61.4	7.0
C-518	Parent	32.33	76.5	100.0	58.4	6.9
	S_1 Progeny	36.86	44.4	78.0	57.3	6.4
Ave. of Buffalo, Rambler, and Rhizoma		51.96	13.9	24.7	51.7	4.8
Ave. of parents		34.95	83.8	96.4	58.5	7.0
Ave. of S_1 Progenies		28.83	42.8	64.2	58.1	7.1
Ave. diff. between parents and S_1 Progenies		-17.5%	-48.9%	-33.4%	- 0.7%	+1.4%

1/ Recovery after cutting scores based on scale of 1 to 9; 1 = rapid recover, 9 = slow recovery.
2/ No plants available for evaluation after first year.

Table 3. Performance of Ark. Syn. P-1 and Ark. Syn. P-2 alfalfa varieties at Fayetteville, Ark. (1962).

Synthetic	Hay yield in tons per acre (12% moisture)	Stand 1/	Percent leaves	Leafhopper injury 2/	Spring vigor 3/	Recovery after cutting 4/	Fall vigor 5/
Ark. Syn. P-1	2.75	62	65.1	4.3	6.9	7.0	6.1
Ark. Syn. P-2	2.84	65	60.4	3.9	6.8	7.0	5.9
L.S.D. at .05 level	N.S.	N.S.	N.S.				
C.V.	8.3%	13.4%	5.8%				

1/ Stand counts were made by the point quadrat method. One hundred points were counted per plot 13 days after first cutting was made. Stand based on the average number of hits per 100 points.
2/ Leafhopper injury scores based on scale of 1 to 9; 1 = no yellowing, 9 = severe yellowing.
3/ Spring vigor scores based on scale of 1 to 9; 1 = high vigor, 9 = low vigor.
4/ Recovery after cutting scores based on scale of 1 to 9; 1 = rapid recovery, 9 = slow recovery.
5/ Fall vigor scores based on scale of 1 to 9; 1 = high vigor, 9 = low vigor.

If, as preliminary results indicate, the performance of S_1 progenies is found to be as reliable as the performance of P.C. progenies for estimating general combining ability, it should result in the following advantages: (1) Eliminate the need for isolation to obtain seed for progeny testing, (2) selfed seed can be obtained in the greenhouse during the winter, (3) difficulties that are often encountered in producing polycross seed in the humid South can be avoided, (4) the homozygosity of desirable genes and gene combinations can be increased and utilized in second or later cycles of phenotypic or genotypic selection, (5) labor and time involved in the establishment and evaluation of clones in a polycross nursery will be eliminated, and (6) clones can be tested on an individual basis without the need for waiting until a sufficient number of superior clones are available for establishing a polycross nursery.

Although selfed progenies usually are less vigorous than parental clones, a wide difference exists among clones in regard to the amount that vigor is reduced as a result of selfing. A part of the seed of a synthetic variety will be the result of selfing, unless completely self-sterile clones are used to synthesize the variety. It seems reasonable to assume from a genetic standpoint, therefore, that it would be advantageous in the synthesis of a variety to use the parental clones which produce the most vigorous selfed progenies.

Evaluating Breeding Lines for Protein Content.--One of the major problems that confronts plant breeders is the evaluation of breeding materials for characters that are either costly or difficult to measure directly. One approach to the solution of problems of this nature would be to find another character that can be easily measured or otherwise identified and that is significantly correlated with the desired form of the difficult-to-measure character. Protein content is considered by many research workers to be the most important single factor associated with forage quality in legumes. In order to determine the actual protein content of potential breeding lines and their various progenies with any degree of accuracy, however, it is necessary to employ costly and time consuming laboratory procedures. Since percent leaves and leaf color are relatively easy to measure in alfalfa and lespedeza in comparison with the measurement of protein content, it appeared that a study of this association in these legumes might provide a useful tool for evaluating breeding material for protein content with only a minimum amount of time and expense involved.

A study of the relationships among percent leaves, leaf color score, and percent crude protein was made in 1959 at Fayetteville for the first and second cuttings of alfalfa. Correlation coefficients for percent crude protein and percent leaves, percent crude protein and leaf color score, percent leaves and leaf color score, percent leaves x leaf color score and percent crude protein, total forage yield and percent leaves, and total forage yield and percent crude protein for the first and second cuttings in 1959 are presented in Table 4. Percent crude protein was positively correlated with percent leaves for the first cutting at the 1% level, r = 0.54. A non-significant, positive correlation coefficient, r = 0.10, was obtained for these two characters for the second cutting. Positive correlation coefficients also were obtained for percent crude protein and leaf color scores both for the first and second cuttings, r = 0.05 and r = 0.21, respectively, but only the correlation coefficient for the second cutting was large enough for significance. Non-significant, negative correlation coefficients for percent leaves

and leaf color scores were obtained for both cuttings, r = -0.10 for the first cutting and r = -0.12 for the second cutting. Significant, positive correlation coefficients were obtained between percent leaves x leaf color score and percent crude protein for both cuttings, r = 0.39 for the first cutting and r = 0.26 for the second cutting. A significant, negative correlation was found between total forage yield and percent leaves, r = -0.50 and -0.33 for the first and second cuttings, respectively, and between total forage yield and percent crude protein, r = -0.48 for the first cutting and -0.31 for the second cutting.

Table 4. Correlation coefficients for percent protein and percent leaves, percent protein and leaf color score, percent leaves and leaf color score, percent leaves x leaf color score and percent protein, total forage yield and percent leaves, and total forage yield and percent protein for the first and second cuttings of alfalfa in 1959 at Fayetteville.

Characters correlated	Correlation coefficients	
	First cutting	Second cutting
Percent protein vs percent leaves	0.54**	0.10
Percent protein vs leaf color score	0.05	0.21**
Percent leaves vs leaf color score	-0.10	-0.12
Percent leaves x leaf color score vs percent protein	0.39**	0.26**
Total forage yield vs percent leaves	-0.50**	-0.33**
Total forage yield vs percent protein	-0.48**	-0.31**

A formula for estimating the percentage of crude protein in alfalfa forage (percent nitrogen x 6.25) was developed from the percent crude protein, percent leaves, and leaf color score data obtained in this experiment by dividing the average percent crude protein by the average percent leaves x the average leaf color score to obtain a constant. The formula as developed for estimating the percent crude protein in alfalfa forage is as follows:

Percent leaves x leaf color score x 0.545 = percent crude protein.

A study of the relationships among leaf shape, percent leaves, leaf color score, and percent protein was made with Korean lespedeza in 1960 at Fayetteville. Correlation coefficients for percent crude protein and percent leaves, percent crude protein and leaf color score, and percent leaves and leaf color score are shown in Table 5. In this study, percent leaves was found to be positively correlated with percent crude protein at the 1% level, r = 0.83. A non-significant positive correlation was obtained between percent crude protein and leaf color score, r = 0.26, and between percent leaves and leaf color score, r = 0.07. In the lespedeza study percent leaves was found to be approximately 4 times as precise as leaf color score for estimating the crude protein in lespedeza forage. It should be pointed out, however,

that the differences among the leaf color scores of the 12 lines used in this study were not statistically significant. Failure to obtain significance in leaf color scores among lines may have been due to the method used for scoring, or it is possible that no significant differences actually existed for the character in the material used for this study. In any event, failure to obtain significant differences among leaf color scores probably accounts for the fact that leaf color was not found to be significantly correlated with percent crude protein.

Table 5. Correlation coefficients for percent crude protein and percent leaves, percent crude protein and leaf color score, and percent leaves and leaf color score.

Characters correlated	Correlation coefficient
Percent crude protein vs. percent leaves	0.83**
Percent crude protein vs. leaf color score	0.26
Percent leaves vs. leaf color score	0.07

Lines with long, broad leaflets with or without the tendency for twinning of the laterial leaflets were higher in percent leaves and in percent crude protein than were lines with small, narrow, or thick leaflets.

In a breeding program with Korean lespedeza where one of the objectives is to develop varieties with a higher content of protein in the forage, a suggested approach on the basis of results obtained in this study is as follows: (1) Screen the original population for lines with a relatively high percentage of leaves. (2) From among the lines with a high percentage of leaves, select those with the longer, broader leaflets and darker green color. (3) Determine the crude protein content of the lines thus selected in the laboratory, and make the final selections on this basis. This procedure was used in the development of Summit lespedeza, the new variety which was released jointly by the Arkansas and Missouri Agricultural Experiment Stations and the U. S. Department of Agriculture in 1962.

In conclusion, results obtained to date from studies of evaluation techniques designed to increase the efficiency of plant breeding efforts have been encouraging. It seems reasonable to assume, therefore, that additional studies of this nature can be expected to provide valuable information for the use of plant breeders.

N. L. Taylor, Kentucky, Presiding

Seed production of forage crops outside their areas of utilization - R. J. Bula

The benefits of a plant breeding program are not realized until the new improved varieties are being used by farmers. Limited seed supplies of new forage varieties, particularly in the humid regions of the U. S., has retarded their use for many years. Many superior forage varieties have passed out of the picture because adequate seed supplies were never made available.

In the late 1940's, concerted effort was put forth by plant breeders and seed production specialists to shift the seed production of improved forage varieties more and more to the specialized seed producing areas of the Western U. S. There the dry, sunny climate and controlled irrigation make conditions ideal for growing and harvesting seed and yields are dependable.

Without the specialized seed production in the West, commercial supplies of many grass and legume varieties would not exist. However, the physiological and genetic characteristics of many forage species complicate their culture for seed production in these Western U. S. areas which are outside the variety's region of adaptation. This is not strange when we consider the genetic variability in the cross - pollinated forage species. "Nature" closely screens the plant population resulting in the elimination of some plant types due to various environmental pressures such as climate, watering, or mowing at the wrong time. Other plant types may produce few seeds to perpetuate themselves under such environmental pressures. The results can be so pronounced as to affect the performance of the variety itself.

An example of this varied response was observed in clones of orchardgrass, birdsfoot trefoil, white clover, and bromegrass. Nurseries were established from vegetative propagations at Prosser, Washington (46° latitude); Logan, Utah (41° latitude); and Shafter and Tehachapi, California (35° latitude). Syn 1 seed produced at these locations is currently being evaluated at Lafayette, Indiana. Comparisons of the vegetative and floral characteristics of the Syn 1 seed populations produced at these various western locations with the Syn 1 seed populations produced in the area where the parental clones are adapted provide the basis for evaluating the magnitude of genetic changes or shifts which has taken place.

Sterility and Incompatibility in Plants - Comments on the Nature of, Methods of Circumventing, and Possible Rewards - E. C. Bashaw*

The literature concerning sterility and incompatibility in plants is voluminous as evidenced by the fact that more than 300 articles relating to this subject were listed in a single volume (1961) of Plant Breeding Abstracts. Much of this research concerns possible methods of overcoming these problems and time available here would hardly be adequate to mention the many approaches that have been made. Since sterility may occur as a result of any breakdown in the the reproductive process, adverse physiological reactions (incompatibility), or as a consequence of environmental factors, the possible forms are almost unlimited. In view of the scope of this subject the comments here will be limited to a brief report on some of the more or less mechanical techniques that have been used successfully or appear potentially useful in plant breeding.

Chromosome doubling--The colchicine technique for doubling the chromosome number in species hybrids to obtain fertile amphiploids is being used so extensively that it hardly seems desirable to spend much time on this subject. Although the method has been used successfully in many cases, doubling chromosome numbers frequently fails to solve the sterility problem. For example, doubling the chromosome number of sommon dallisgrass resulted in dwarf plants that were considerably less fertile than the normal.

* Contributions by Arne Hovin, Robert Buckner and R. C. Leffel

Regarding the possibilities and limitations of chromosome doubling, Dr. R. C. Buckner offered the following comments. "It is my opinion that one cannot generalize on this problem. As an example, I have not been able to double the chromosome number of the perennial ryegrass - tall fescue hybrids and obtain fertile amphiploids; but, when annual ryegrass - tall fescue hybrids are treated, relatively fertile amphiploids are obtained. Doubling the chromosome number of the annual ryegrass - tall fescue hybrids does not completely solve the fertility problem. Some of the amphiploids are completely sterile and others have good seed set. Consequently, we are now selecting amphiploids with good seed set and intercrossing these plants. Although we may be able to overcome the sterility problem completely by this method, I am somewhat suspicious that cytoplasm may be playing a part in the problem also. All of the ryegrass - tall fescue hybrids have been made using ryegrass as the female parent. We now have plant materials that may enable us to determine whether cytoplasm is also responsible for the sterility problem. Thus, it seems that sterility in the ryegrass - tall fescue hybrids is not only chromosomal but genic and maybe cytoplasmic as well. Therefore, just doubling chromosome numbers of sterile hybrids does not always solve the sterility problem, but it may help."

<u>Embryo culture and transplanting</u>--The barrier of post-fertilization abortion, if mainly conditioned by malnutrition, may be overcome by embryo culture. This technique is by no means new and according to Keim (1953b) probably dates back to the work of Hanning in 1904 and Knudson in 1916. There have been many reports of successful use of embryo culture. The work with <u>Trifolium</u> hybrids by Keim (1953b) and by Hovin (1962) provide excellent examples of the successful use of this technique. Hovin stated that the success of artificial cultured embryos depends partly on (1) when removed, (2) the nutrient medium, (3) source material, (4) physical facilities, and (5) the skill of handling of materials.

Grafting or transplanting embryos has also been used successfully in several crops to overcome problems of non-nutritive or incompatible endosperms. Hall (1954) transplanted wheat embryos to rye endosperm and secured plants which were then used in interspecific wheat-rye crosses. A number of Russian workers including Kononva (1960) and Tovmasjan (1960) have reported genetic effects from embryo transplants but other workers have not been able to verify these results.

<u>Grafting</u>--The possibility of producing graft hybrids and the use of grafts to overcome sterility or incompatibility has been investigated for many years. In 1902 R. H. Biffen of Cambridge reported successful grafts with a number of Trifolium species. Biffen mentions a report by Daniel in 1898 (Ann. d. Sci. Nat.) in which the latter claimed that "stock and scion mutually affect one another, and in some cases the changes so induced became hereditary." None of Biffens grafts showed any signs of genetic effects.

In recent years Russian and Polish workers have reported successful vegetative hybrids by grafts and also claim a reduction in incompatibility when parent plants are first grafted before attempting hybridization. Dyba (1949) reported vegetative hybrids of both grasses and legumes. Starzycki (1959) claims that he was able to cross white and red clover after grafting the parents. Claims of the Russians are exemplified by the report of Gloushtshenko (USSR) at the 1958 International Genetics Congress in which he stated "Our experiments of many years have shown that by means of grafting one can obtain hybrid forms which are similar to those obtained by

sexual hybridization." The Russian work has been challenged by numerous investigators and current literature in this area is voluminous. At the present time the possibility of true graft hybrids seems highly unlikely and most investigators are reluctant to accept claims of a reduction of incompatibility by grafts. Somewhat similar results have been published by a few workers outside Russia and Poland. Sulbha and Swaminathan (1959) reported that in two species hybrids of Jute prior grafting of the parents increased fruit set from 42.3% to 66.5% in one case and from 5% to 25% in another. This data was based on observations of early embryonic development and they found no increase in actual seed set. The number of observations was not reported.

In spite of the doubt surrounding graft hybrids some interesting and potentially useful affects of grafting have been reported. Frankel (1956, 1962) reported graft induced transmission of cytoplasmic male sterility to progeny of male fertile petunias. Normal male fertile plants grafted on male sterile stocks yielded some male sterile progeny. The work of Edwardson and Corbett (1961) verified in general asexual transmission of cytoplasmic male sterility through grafts. Evans (1962) has reported successful use of grafting as a screening technique for compatible genotypes in hybridization of Trifolium species. In a study of 21 species combinations and their reciprocals she found that the percentage embryos set on hybridization of graft-compatible genotypes was significantly greater than on hybridization of graft-incompatible genotypes. Based on graft evaluations, compatible combinations produced over 10 times more embryos than incompatible combinations. Contrary to the Russian reports grafting did not significantly increase crossability. Addison and Travares (1952), working with species of Theobrama, also found that the degrees of success of interspecific hybridization and of grafting showed a strong positive correlation. They stated that "whether the success of hybridization and the outcome of grafting have a common physiological basis is a matter of speculation."

Recent serological studies suggest a possible basis for the effects of grafting. Gell, Hawkes and Wright (1960) used serological methods based on the immuno-electrophoretic protein spectra of species of Solanum to indicate a scheme of relationships between the species. They noted that the scheme tended to coincide with the crossability results for these species. The chemistry of incompatibility reactions is being investigated by numerous workers and the results could indicate practical methods for overcoming incompatibility.

Clipping or grafting styles and treatment or substitution for stigmas--Simple morphological features such as differences in style length of species may serve as a barrier to hybridization. In such cases cutting back the long styles may prove effective. Mangelsdorf and Reeves (1931, 1939) used this technique 30 years ago with some of the early Zea-Tripsacum crosses.

Where incompatibility factors are involved, stigma grafts may be of value. By grafting compatible stigmas and style segments onto otherwise incompatible stock Hecht (1960) was able to obtain pollen tube growth through much of the remaining portion of the incompatible style. With further investigation this technique may prove useful in crossing otherwise incompatible plants.

The removal of incompatible stigmas and germination of pollen in agar or other suitable medium on the tip of the style offers another possible approach. Where

pollen failed to germinate on incompatible stigmas, Evans and Denward (1955) found that painting the stigma with a solution of the hormone B - napthoxy - acetic acid, which acted as a substrate for the pollen, promoted germination in many cases. Other chemicals have also been used for this purpose and simply scraping the surface of the stigma has proven effective with some species.

Miscellaneous methods--There are numerous other methods that have been employed to overcome sterility and incompatibility. Some of these have considerable promise in specific cases and are mentioned briefly with a few references for those interested in further information.

Hecht (1962) believes that specific temperature treatment may be of value. He found that if styles of Oenithera organensis are excised at their junction with the ovary, and then treated at temperatures just below what will kill their cells (50° - 57°C.), some change occurs reducing the intensity of the incompatibility reaction. After 5 minutes at this temperature, whether the styles are immersed in warm water or in moist air, Hecht found that a number of the otherwise incompatible pollen grains germinated and grew through the stigma and well into the style.

There is considerable evidence that the use of excess or foreign pollen may be of value in some cases where incompatibility is apparently due to physiological factors. Nesterov (1956) observed that "when self pollen, provided it is a small quantity, settles on the pistils during pollination by pollen from another variety its effect is not always harmful. On the contrary, in some instances when the two varieties withstood all attempts to be crossed, the addition of maternal pollen in a very small percentage assisted the reception of foreign pollen."

Brewbaker and Majunder (1961) observed a significant effect of decreasing population size on pollen germination in 8 Angiosperm genera. Reduction of pollen germination percentages occurred linearly in Petunia inflata below 200 grains. Water extracts of pollen and other plant parts contained a factor or factors which could overcome fully the population effect. They proposed that the pollen growth factor or factors (PGF) may be consumed during growth and that incompatibility (of the S allele type) inhibits the production or utilization by, or transfer to the pollen of PGF. Although not stated in this report, an effective means of artificially supplying the PGF during pollen tube growth might be a practical means of overcoming incompatibility. The study of the physiological and biochemical nature of incompatibility reactions comprises a vast area in itself. The works of Lewis (1942, 1949) and Makinen and Lewis (1962) are cited for further information in this area.

Propagation of weak or deficient hybrids (Smith 1943, 1954) offers another possibility for overcoming the effects of sterility and incompatibility. The use of radiation and revertible mutations of the S gene has also been reported (Lewis and Crowe, 1953). Some progress has been made in avoiding pollen germination difficulties and incompatibility between pollen tube and style by bud or post-flowering pollination. At least one investigator (Hecht, 1958) has observed a favorable effect from insect injury.

It is obvious that much ignorance yet surrounds the problems of sterility and incompatibility in plants but considerable progress has been made in many instances. At the present time it appears that any reasonable approach should not be discounted without due consideration.

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Examples of Contributions by Different Disciplines Toward Coordinated Improvement of Forage Crops - Plant Cytogenetics - Ian Forbes

Cytology and genetics first developed as separate sciences. When chromosomes were recognized as the bearers of the genes which control most of the inherited characters of plants and animals, the science of cytogenetics was born. Previously, plant breeders had used purely such genetic methods as existed. Some forage crops are still being bred in the absence of adequate cytogenetic information on the crop.

Plant cytogenetic research has often contributed basic information about a crop needed for formulation of an intelligent breeding program and valuable breeding materials that might otherwise never have been available to plant breeders. Both types of contributions were made through cytogenetic research (by G. W. Burton and I. Forbes) at Tifton, Georgia, to bahiagrass (Paspalum notatum Flugge) improvement.

Pensacola bahiagrass reproduces sexually. It has 2n = 20 chromosomes, regular diploid meiosis, and several desirable agronomic characteristics not present in naturally occurring tetraploid (2n = 40 chromosomes) bahiagrasses. Natural tetraploids reproduce by obligate apomixis, behave mostly as autotetraploids at meiosis, and have desirable agronomic characters not present in Pensacola. Conventional breeding to obtain recombination of characters within natural tetraploids or between them and Pensacola has been prevented in the past because the few hybrids obtained were invariably obligate apomicts. When natural tetraploids were used as female parents, only unreduced aposporus eggs functioned in the production of occasional hybrid seeds.

By treating Pensacola bahiagrass seeds with aqueous colchicine and screening the surviving seedlings by cytological and seed-fertility methods, ten induced-autotetraploid plants were obtained. These plants were completely sexual. Obligate apomixis in natural tetraploid bahiagrasses was broken by hybridizing them with these sexual induced-autotetraploid Pensacola bahiagrasses as female parents. Unlike previous hybrids involving natural tetraploids, the great majority of the induced-tetraploid X natural tetraploid hybrids were sexual, and all investigated had 2n = 40 chromosomes.

Four hybrids between 3 induced-tetraploid plants and 2 natural tetraploid plants gave sexual to apomictic ratios in the F_2 which suggested that obligate apomixis is controlled by a very few recessive genes. Three of the 4 crosses gave F_2 frequencies that fit the autotetraploid 35:1 single-gene ratio. The failure of the fourth hybrid to fit this ratio and the appearance of some apomicts in the F_1 indicate the operation of modifying factors.

The development of this method for breaking obligate apomixis in naturally occurring tetraploids has released many genes heretofore unavailable to plant breeders and has already given rise to very promising new plant types. The importance to bahiagrass improvement of a method that will permit the manipulation of obligate apomixis to fix heterosis and desirable genotypes is apparent.

Plant Physiology - R. E. Burns

Historically, the work of Garner and Allard on photoperiodism, which enabled the breeder to control the flowering time of his plants, is an outstanding example of the contribution of plant physiology to plant breeding.

Today a plant physiologist can contribute much to a coordinated forage improvement program. These contributions include studying environmental conditions necessary for maximum growth, developing rapid methods for screening large populations, finding conditions necessary for maintaining seed stocks, studying causes of atypical plant characteristics in breeding lines, determining forage quality associated with biochemical constituents, studying methods for obtaining the maximum or minimum number of

cross-pollinated seed, and studying plant characteristics contributing to maximum production.

The list could be expanded indefinitely. Each new genus and each step in the breeding program will increase the number of physiological problems. If necessary, one plant physiologist can assist with several breeding programs.

Plant Pathology - Homer D. Wells

Some of the weapons available to pathologists for use in combating plant diseases include fungicides, crop rotations, and other management practices, and plant breeders. The plant pathologist does not try to convert himself into a fungicide or a crop rotation, etc., and should also resist taking on the image of a plant breeder. At Tifton, a team composed of entomologists, agronomists, animal nutritionists, engineers, breeders, nematologists, and pathologists are assigned responsibilities for improving forage crops. Most experiment stations have disciples of all or most of these disciplines. Professionals in these disciplines, in many instances, are assigned responsibility for handling related problems for a wide range of commodities and concentrate their efforts where liklihood of success is good and cooperation is "palatable". Thus, their services are available to forage crop programs if we can demonstrate a place of service and of a cooperative spirit.

Team efforts of pathologists and breeders have resulted in locating disease resistance in blue lupine, determining the inheritance of disease resistance, and developing elite breeding lines. Teamwork efforts have resulted in establishing an elite breeding line of rust-resistant ryegrass and cataloguing disease reactions of a wide range of breeding lines of a number of other grasses. Team efforts of pathologists, entomologists, and breeders have resulted in developing a system employing a systemic insecticide for the control of bean yellow mosaic virus in yellow lupine. This system was used also by the pathologists in cooperation with the plant breeder in freeing his blue lupine breeding lines of the seed-borne cucumber mosaic virus.

ANIMAL SCIENCE

C. B. Browning, Mississippi, Presiding

Forage needs of the dairy farmer - M. E. McCullough

Dairy farms have become large businesses. The average dairyman now has a capital investment of about $1000 per cow. Like all farming enterprises, today's dairyman operates on a narrow margin of profit-thus, emphasis is on efficiency of production. To utilize 100 tons of hay with a TDN of 55% requires the addition of 126 tons of grain while 100 tons of hay with a TDN content of 62% will produce the same amount of milk when fed with 64 tons of grain. The difference in feed cost for the two hays is about $2000. Our dairy farmers obviously need to produce, store and utilize the highest quality forage which they can grow on their farms.

Forage testing - a means of improving quality - G. E. Hawkins

Most dairymen now realize that the old "eyeball-sniff test" does not give a

sound evaluation of the nutritive quality of forages. Hence, widespread interest has developed in forages testing on a scientific basis.

Many methods of predicting forage quality have been proposed. These include chemical analyses, artificial rumen, nylon bag in rumen fistulated animals, and cutting date (or stage of maturity). The chemical analysis method seems to have the most widespread use and it is the method discussed here.

There are at least three components of forages that yield relatively high correlations with digestibility of the forage. These components are crude protein, crude fiber, and lignin. Lignin is relatively difficult to determine and the procedure is time consuming. For this reason, lignin is not used extensively in forage testing programs. Crude protein and crude fiber are the two components of forage that are widely used as indicators of the nutritive quality. Brierem analyzed metabolizable energy data from America and Europe and found that the net availability of metabolizable energy "fell steadily and linearly as the crude fiber" content of the ration increased (2). Also, Mollgaard (5) found that the net energy value of feeds for lactation depended on the animals supply of protein. Studies by the author indicate that intake of Coastal Bermudagrass hays by steers is correlated with both crude fiber ($r = -0.835$) and crude protein ($r = 0.828$). Thus, there is justification for using these forages components in predicting nutritive quality.

Definitions of the components used in forage testing appear appropriate. Crude protein is the nitrogen content of forages multiplied by the factor 6.25. It includes both true proteins and non-protein nitrogen-containing compounds. Crude fiber is the residue, less ash, resulting from "timed boiling in dilute acid and dilute alkali." The method is essentially that developed by Henneberg & Stohmann in 1860. Crude fiber is not a single chemical entity; it includes celluloses, pentosans, hemicelluloses, lignins, and possibly others. Also, the ratio of these chemical entities in crude fiber are not constant. For example, the crude fiber in early cut forages contains a relatively high percent of cellulose, whereas that in mature forages contains less cellulose and a higher percent of lignin.

It is to be expected, therefore, that crude fiber from different plant materials would vary in digestibility. Our interest, however, does not lie in the digestibility, per se, of the plant material, but rather in the net availability of the digested energy for useful purposes. The net availability of feed energy to animals is referred to as "net energy." Energy values of forages predicted from chemical determinations are referred to as Estimated Net Energy (ENE).

Even if the crude fiber were a single chemical entity in all forages, there are other limitations to the "forage testing" concept as a means of predicting the value of forages for animal performance. Other than the chemical composition of the plant limitations of forage evaluation methods that affect net energy value of feeds include: (a) the ratio of other feeds in the ration, (b) the quantity of the ration consumed, and (c) the body function for which it is used. For example, work by Forbes and Kriss (3) indicates that utilization of metabolizable energy for milk production is approximately 20% greater than its utilization for increase in body substance. Thus, no single evaluation of a forage, either biological or chemical is accurate for all body functions under all sets of conditions. Hence, it appears necessary to make use of an evaluation that will apply for an average set of conditions.

Proper sampling is essential in obtaining a meaningful analysis that will represent the average composition of the entire lot of harvested forage. In testing hays a minimum of 19 bales (4) must be sampled to obtain material that is representative.

The Pennsylvania Forage Testing Service prediction equation (1) is the basic method used in this area for estimating forage quality from chemical analyses. ENE values of Coastal Bermudagrass hays obtained from chemical analysis, using the Pennsylvania State Prediction equation, were compared with those obtained from TDN determined by digestion trials. The ENE values predicted from chemical analyses of the forages always were higher than those calculated from digestion trial TDN. The relationship between the values obtained by the two methods followed a definite pattern. Also, FCM production by cows fed the 15 Coastal Bermudagrass hays was correlated ($r = 0.583$) significantly with ENE values determined from chemical analyses by the prediction equation.

In summary it may be stated that the Pennsylvania State method for predicting forage quality from chemical analyses is a useful but imperfect approach. Studies by the author indicate that within forage species modifications of the general equation based on digestion trial data will increase the accuracy of the predicted nutritive quality of forages.

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<u>Lignin and Forage Quality</u> - R. H. Brown

Lignin is a complex plant constituent for which a definite chemical structure is not known. Analytically it may be defined as the cell wall material of plants which is insoluble in 72% H_2SO_4. Lignin is very resistant to attack by rumen microorganisms. In addition, it influences the susceptibility of other plant fractions to microbial breakdown.

As plants age, their dry matter digestibility decreases. At the same time

lignification of plant tissue is impressive. There is usually a high degree of correlation between lignin content of forages and their digestibility. As lignin content increases, digestibility of cellulose, crude fiber, hemicellulose, and nitrogen free extract decreases. Digestibility of water soluble carbohydrates seems to be unaffected by lignification.

Two possible ways in which lignin interferes with digestibility have been put forward: 1) Lignin is toxic to rumen microorganisms and 2) Lignin mechanically covers cell wall materials and prevents contact between rumen bacteria and such materials. In experiments in which isolated lignin was added back to a forage ration, nutrient digestibility was not affected. Addition of purified lignin to an *in vitro* digestion mixture did not affect breakdown of cellulose. This indicates that lignin is not toxic. Increases in microbial breakdown of fibrous constituents of forage have been obtained both *in vivo* and *in vitro* by treatments which remove lignin or partially degrade it.

The physical separation of bacteria and cellulosic materials by lignin becomes even more important in light of the fact that rumen bacteria apparently produce no extracellular cellulases. The bacterial cell must be in physical contact with the cellulose to break it down.

The relation of lignin content of plants to the proximate analysis of such plants is not always the same. Only about 1/4 of the the lignin in orchardgrass is recovered in the crude fiber; about 3/4 of the lignin in alfalfa appears in this fraction. The amount of lignin recovered in crude fiber varies with age of the plant.

Present knowledge of the lignification process is so insufficient that control of lignin content is not practical. Plants cut in the immature stage are low in lignin but yield is also low. Varieties differ in lignin content but the extent of variability is not known. No chemical or metabolic control is likely until the lignification is much better understood.

Influence of Nitrogen Fertilization on Forage Quality - W. R. Meredith

The term "forage quality" has been used in many diverse ways by many people. It has usually been related to the feeding efficiency of various forages. In this respect, the mineral, vitamin, crude protein and energy content, etc. is often referred to. However, from a practical viewpoint, it is easiest to consider forage quality and production per animal as being synonymous. Therefore, in this review, forage quality and production per animal will be considered as such.

The factors which are most often discussed when forage quality or animal performance is described are: (1) chemical composition, particularly crude protein, (2) digestibility, and (3) *ad libitum* intake.

Part of this review therefore will be directed to the influence of nitrogen fertilization (N) on these factors.

1. Influence of N fertilization on chemical composition.

Increasing the level of N applied has consistently resulted in forage higher in crude protein and lower in nitrogen-free extract. The work by Fisher (9) and by Ramage (16) are typical of this response. Waite (20) has shown that it is the

soluble carbohydrate fraction which decreases. Digestion experiments have also shown that apparently the increased crude protein content is more digestible. Knox (12) has shown that the lignin content of heavily fertilized Coastal Bermudagrass is apparently inversely related to the leafiness of the forage. When fertilization increased leafiness, the lignin content was decreased and when leafiness was decreased the lignin content increased.

II. Influence of N fertilization on digestibility.

In general increased N fertilization has had no appreciable effect on digestibility of forages, Table 1. The data presented show 21 comparisons between a low level of nitrogen and one or more higher levels. The average digestibility of the lowest N treatments in these 21 comparisons is 60.81, that for the highest N treatments is 61.25. This small difference of +.44 in favor of the higher N treatment certainly is not large enough to be considered of any practical value.

There are some exceptions to this general rule. For instance, Chalupa (4) and Alexander (1) obtained higher digestibility coefficients for the higher N rates. In contrast to this Poulton (19) found that increased N rates resulted in lower digestibility of Climax timothy.

III. Influence of N fertilization on ad libitum intake.

There is less data available on the influences of N levels on forage intake than any of the other factors discussed. This is unfortunate since many animal people regard this factor as the most important one concerning forage quality. A limited amount of data is given in Table 2. It would appear that under the usual nitrogen levels and under the usual management practices that N application has little influence upon forage intake.

Some possible exceptions to this generality would appear to be in the fall or very early spring. Elder (6) has reported that increased animal performance has been observed in the early spring as a result of N fertilization. Apparently, the higher N levels promote more early growth of the grasses and thus make it more available to the animal. In these cases intake is increased simply because there is more forage available (increased yield).

IV. Influence of N fertilization on animal performance.

The best indicator of the influence of N on forage quality is the actual performance of animals in properly conducted animal experiments. If the increased crude protein content and digestible protein is of any value and if there is any increase in energy intake due to increased N levels it should be reflected in the performance of the animals.

The influence of N on the rate of daily gain for beef animals for several experiments is given in Table 3. It would appear from these experiments that N fertilization neither appreciably increases or decreases forage quality.

Table 1. Influence of nitrogen on digestible energy % of grasses.

Author	Species	N. Fert.	Digestibility
Alexander (1)	Coastal bermuda BF(S7)	50	52.5
		100	53.6
	BF(48)	50	55.2
		100	53.8
	AF(57)	50	48.9
		100	53.9
	AF(48)	50	49.3
		100	54.3
Browning (3)*	Coastal bermuda	50	58.6
		300	61.5
Ferguson (8)**	Ryegrass	0	62.3
		40	62.5
		0	59.2
		48	60.6
Minson (14)** S-23	Ryegrass	0	61.6
		52	59.3
		87	60.9
S-24	Ryegrass cut 5-23	0	71.8
		52	69.1
	cut 6-16	0	57.6
		52	56.9
	cut 6-5	0	61.6
		87	63.0
	Orchardgrass cut 5-23	0	66.1
		52	64.4
	cut 5-6	0	60.4
		52	56.9
	cut 2-10	35	65.2
		175	66.7
Poulton (17)	Orchardgrass	100	64.1
		200	63.6
		400	63.4
Gordon (10)	Orchardgrass	0	63.8
		400	65.6
Chalupa (4)	Reed Canarygrass	0	60.8
		100	57.3
		200	63.4
Barth (2)	Reed Canarygrass	0	63.2
		100	58.1
		200	62.3
Markley (13)	Bromegrass	25	58.0
		125	57.9
		225	61.9
Colovoa (5)	Bromegrass cut 5-29	50	70.8
		200	71.6
	cut 6-9	50	64.6
		200	63.1
	cut 6-20	50	56.9
		200	57.3
Poulton (16)	Timothy	0	66.2
		50	65.6
		100	64.3
		200	62.1

* Digestibility dry matter BF = Before frost
** Digestible organic matter AF = After frost

Table 2. Influence of N fertilization on animal intake

Author	Species		N. fertilization	Dry matter intake[1]
Browning (3)	Coastal bermuda		50	1.94
			300	1.92
Alexander (1)	Coastal bermuda	BF[2](47)	50	15.1
			100	15.8
		BF(48)	50	14.6
			100	14.1
		AF(57)	50	12.7
			100	15.5
		AF(58)	50	11.5
			100	14.3
Gordon (10)			0	1.78
			400	1.37

1/ Intake expressed as pounds of dry forage consumed per 100 lbs. body weight for Browning (3) and Gordon (10). Actual animal intake per animal (dairy heifers) for Alexander (1).

2/ BF = Before frost
AF = After frost

Table 3. Influence of nitrogen on production per animal

Author	Species	N. Fert.	Av. daily gain
Stephens (19)	Bahiagrass	50	1.02
		100	.92
		200	.94
Evans (7)	Dallisgrass	0	1.30
		40	1.68
		80	1.57
		160	1.59
Mott (15)	Bluegrass	0	1.16
		120	1.11
Hogg (11)	Coastal bermuda	100	1.13
		200	1.22
		300	1.23
		400	1.32
	Coastal bermuda +	120	.96
	+	LaS-1	1.41

Nitrogen fertilizer distributors should be satisfied that increased N fertilization increases yield without decreasing forage quality. They still may argue that the feeding of forages higher in crude protein will allow livestockmen to reduce their protein supplement for high producing animals. However, the experimental evidence supporting this argument is limited.

V. Summary

Nitrogen fertilizers are applied to forage crops primarily to increase their yield and carrying capacity. Increasing the N rate increases the crude protein content and also its apparent crude protein digestibility. Conversely as N rates are increased the NFE and more soluble carbohydrate fractions are decreased. The influence of N on crude fiber, ether extract and lignin content has been more variable. In general, there has been no appreciable increase or decrease in forage digestibility or intake as a result of increased N fertilization. Various grazing experiments on the more southern type grasses have shown no appreciable increase or decrease in production per animal.

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Plant and Animal Factors in Grazing Systems - R. E. Blaser

Grazing management embodies judicious compromises between plant and animal factors to obtain high animal and high acre outputs.

Plant management involves an interrelationship of leaf area and reserve carbohydrates when other factors that influence growth are favorable. From the viewpoint of leaf area, near maximum regrowth occurs when light interception is near 100%. The optimum leaf area (sq. ft. of leaf area per sq. ft. of sod) ranges from 4 to 20 among different species where there is near maximum light interception and growth. The ideal is to maintain a leaf area where near optimum dry matter production occurs. Some plants may be grazed continuously and others must be grazed rotationally.

Reserve carbohydrates serve as energy for regrowth and survival during periods of stress. During grazing they are alternately accumulated and reutilized for new growth and tillering. With plants such as alfalfa, the initial regrowth occurs from

energy and reserve carbohydrates in the roots and rhizomes. As the size of the leaf area increases, reserve foods are manufactured more rapidly than needed growth requirements; thus, food reserves are restored.

Leaf area and food reserves do not operate independently as it is impossible to obtain a high leaf area without also influencing the magnitude of the carbohydrate reserves. When considering these factors in grazing management, the larger perennial grasses and legumes should be grazed rotationally where there is a reasonably long rest period after grazing and a short grazing period. Morphologically small and prostrate species may be grazed either rotationally or continuously, there being little benefit from rotational grazing.

Animal output when grazing a given species or mixture depends on stocking pressure and selective grazing. Output per animal is usually as good or better from continuous than for rotational grazing,; there is usually more selective grazing under continuous grazing because feed is accumulated in situ. Under rotational grazing, selective grazing is high when animals are first put in a lot and very low toward the end of a grazing period as most of the herbage is utilized. Animals select herbage that is high in dry matter digestibility, high in protein and low in crude fiber.

In actual practice, animal outputs during the early season flush growth period are usually higher for continuous than for rotational grazing because there is very high selective grazing. During the latter half of the grazing season, animal outputs are often higher for rotational than for continuous grazing because the accumulated herbage under continuous grazing practices becomes unpalatable and there is also limited selection because of a shortage of herbage. The primary advantage of rotational grazing for morphologically erect or semi-erect productive species is an increased carrying capacity and increased longevity of plants.

Rotational grazing has a real advantage when incorporated into the 12-month forage program where mixtures are used flexibily for silage, hay and/or grazing. More land and fields are grazed during the summer, fall and winter months than during the flush spring season with such a plan. Some fields and mixtures are used for silage and then rotationally grazed, other mixtures are used for silage, hay and rotational grazing and others are used only for grazing. The use of silage, hay and grazing in the 12-month forage plan is the only way to obtain a dependable supply of feed.

PLANT PATHOLOGY

Homer D. Wells, Georgia, Presiding

Fungitoxicity in High- and Low-Organic Soil in Relation to Survival of *Sclerotium rolfsii* - E. A. Curl

Sclerotium rolfsii Sacc. is a soil-inhabiting facultative plant parasite with a wide host range and capacity for long survival in soil. Its persistence is attributed primarily to resistant sclerotia, while little is known of the fate of mycelium in natural soil. With more information on the relation of natural biotic phenomena of soil to survival of *S. rolfsii*, biological means of suppressing the fungus may become feasible.

The samples chosen for study were of contrasting organic matter content and were designated as HO (high organic) and LO (low organic). Relative populations of soil microorganisms were determined. Mycelium of the pathogen, grown on nylon-gauze squares (18 x 18 mm), was buried in natural and sterilized potted soil from each sample for 7 to 16 days. The squares were recovered, washed and stained, and the number of mycelial filaments per mesh determined microscopically. Laboratory-grown sclerotia of the pathogen were buried, recovered, and their viability and microbial infestation determined.

There was little difference in total numbers of fungi or bacteria in the two soils, but Streptomycetes were more abundant in the LO soil. Trichoderma viride was usually the predominant fungus in the HO soil and Aspergillus sp. predominated in the LO soil. Destruction of mycelium of S. rolfsii in the HO soil was complete in less than 13 days, while mycelium persisted in the LO soil throughout the experimental period of 16 days. Mycelium in sterilized soil of either sample was not destroyed but eventually lost viability. All sclerotia recovered from sterilized soil after 16 days germinated, whereas, 21% of those from natural HO soil and 33% of those from natural LO soil germinated. Little difference was found in the degree of microbial infestation of sclerotia in the two soil samples.

Crown and Root Disorders of Coastal Bermudagrass - R. T. Gudauskas

Localized rotting of stems, roots, stolons, or crowns was frequently associated with die-back of Coastal Bermudagrass (Cynodon dactylon (L.) Pers.) at six locations in southern Alabama in 1962. The majority of necrotic areas occurred around or could be traced to wounds that appeared to be insect inflicted. Fungi and bacteria associated with these necrotic tissues were isolated from plants collected at the various locations, and the predominate isolates were tested for pathogenicity.

Species of the fungus genus Helminthosporium comprised over 50% of all isolates from all locations. Of these, H. rostratum, H. spiciferum, and an unidentified Helminthosporium sp. predominated. Numerous isolates of the three fungi were tested for pathogenicity on Coastal Bermuda plants in the greenhouse. The fungi were increased on an oat-seed medium and inoculation was accomplished by adding the infested oat seed to sterile soil in which plants were growing. Stems, roots, and crowns of some test plants were wounded with a needle, while others were left unwounded.

Isolates of H. rostratum and the unidentified Helminthosporium sp. were pathogenic on both wounded and non-wounded plants, whereas noticeable infection by H. spiciferum occurred only in wounded plants. Typical symptoms of infection were: rotting in stem, crown, root and stolon tissue, yellowing and browning of leaves, and general weakening of plants. The extent and severity of the rots varied among isolates but invasion was usually more pronounced in wounded plants. Data obtained during 1962 pointed out the significance of insect or other wounds in roots and crowns of Coastal Bermudagrass. Such wounds appeared to serve as additional portals of entry for fungi which brought about decay of invaded tissues.

Reproduction and Pathogenicity Studies with Nematode Associated with Forage Crops in North Carolina - N. E. McGlohon, J. N. Sasser, and R. T. Sherwood

Plant-parasitic nematodes of the genera Hoplolaimus, Trichodorus, Tylenchorhynchus, Pratylenchus, Xiphinema, Meloidogyne, Heterodera, Criconemoides, and Paratylenchus were found in soil samples from 217 forage crop fields in North Carolina. Xiphinema, Tylenchorhynchus, Helicotylenchus, and Trichodorus were the more common forms. Some genera were more prevalent in one soil type than in others.

Ladino clover, Kenland red clover, Atlantic alfalfa, Korean lespedeza, sericea lespedeza, tall fescue, orchardgrass, crabgrass, Bermudagrass, dallisgrass, Pensacola bahiagrass and Italian ryegrass were inoculated in the greenhouse with Tylenchorhynchus claytoni, Trichodorus christiei, Hiplolaimus tylenchiformis, Helicotylenchus nannus and Paratylenchus projectus with 1000 nematodes per 6-inch pot. After 9 months there was a moderate to large increase in the number of nematodes in most nematode-crop combinations. Numbers of nematodes decreased only in the following combinations: Hoplolaimus tylenchiformis with alfalfa, dallisgrass, and Pensacola bahiagrass; Helicotylenchus nannus with alfalfa; Paratylenchus projectus with dallisgrass.

In the greenhouse test significant reduction of root weights occurred as follows: with Hoplolaimus tylenchiformis all crops except alfalfa, dallisgrass, Pensacola bahiagrass and Bermudagrass; with Trichodorus christiei all crops except ryegrass and bahiagrass; with Helicotylenchus nannus all crops except alfalfa, sericea, orchardgrass, dallisgrass, bahiagrass, and Bermudagrass. With Tylenchorhynchus claytoni root damage occurred only with Korean lespedeza, crabgrass, and ryegrass, and with Paratylenchus projectus it occurred with Korean lespedeza.

In the greenhouse there was a significant reduction of shoot weights for many of the treatments, but this usually appeared only after several harvests were taken. Dallisgrass, Bermudagrass, ryegrass and bahiagrass were usually unaffected. Fescue and orchardgrass shoots were damaged only by Hoplolaimus tylenchiformis and Trichodorus christiei, and alfalfa was damaged by T. christiei. These two species and Helicotylenchus nannus reduced red and Ladino clover top growth. Sericea lespedeza was damaged by all but Paratylenchus projectus, but Korean lespedeza was quite susceptible to injury by all 5 species. Meloidogyne hapla injured all the legumes, and M. incognita injured all the legumes except Atlantic alfalfa in separate tests.

The Use of Soil Temperature Tanks in a Screening Program to Select White Clover Plants Resistant to Pathogenic Soil Fungi - J. E. Halpin

The soil temperature tanks at Clemson represent one of the facilities available for the study of environmental factors important in the development and severity of white clover diseases. These tanks facilitate the study of the effects of the presence of various individual soil fungi on the growth of clover, over a wide range of temperatures as compared to similar conditions where the soil fungi are absent. An example of such a fungus is Fusarium roseum.

F. roseum has been shown to be:

a. A common isolate from diseased white clover stolons in various locations in the Southeast.

b. Capable of inciting several important disease symptoms on clover seedlings, especially during the summer months when soil temperatures are high.

c. Capable of reducing the stands of white clover in field plot, greenhouse, and growth chamber experiments.

In the studies reported here, information was obtained as to:

a. The effect of temperature on the capacity of cuttings of white clover clones to survive in soils of various uniform temperatures and the effect of these temperatures on the resulting growth of the clover.

b. The ability of cuttings of white clover clones to survive in soil infested with *F. roseum* at various temperatures.

c. The effect of pre-treatment (induced flowering or limited flowering on the capacity of cuttings from selected white clover clones to produce adventitious roots and survive in soil infested with *F. roseum* and maintained at a constant temperature of 80°F.

In the earlier studies, temperature tank pans were prepared by half filling with sterile soil, covering with two layers of sterile sand, watering, and placing 24 cuttings in each pan. *F. roseum* infested pans were prepared in the same manner except that the bottom sand layer had been previously mixed with mycelium of the fungus prior to placing in the pans. Root nodulating bacteria were dusted over the soil surface of all pans. Notes were taken at periodic intervals for 30 days following transplanting and at the end of the test period. The cuttings which were still alive were counted, dug, their above-ground and below-the-soil-line portions being rated as to size, evidence of disease symptoms, and root nodulations. These studies were repeated.

In later studies, the pans were prepared as in the *F. roseum* pans for the earlier experiments. Selected white clover plants were divided into two clonal cuttings each. One cutting was placed in a growth chamber having a light cycle of 13 hours light, 11 hours of darkness, thus reducing flowering; the other group of cuttings received a split light pattern (12 light, 5-1/2 dark; 1 light; 5-1/2 dark per 24 hour period) to stimulate flowering. Approximately 10 times as many floral heads resulted in the latter than in the former treatment. Cuttings were made from each of these plants and placed in the *F. roseum* infested pans in the tanks at various temperatures. Observations were made for 15 days as to survival and growth.

F. roseum was shown to be pathogenic over the entire range (45-90°F.) tested, pathogenicity increasing with temperature. When *F. roseum* was absent, the clover was free from symptoms of root or stolon rots as well as other disease symptoms.

Clover was the tallest at 90°F.; the greatest root system and the best nodulation was observed at 60°F.; and the poorest roots were obtained at 90°F. Growth was the most normal (not stunted nor leggy) at 60°F. over all.

Pre-disposing plants to induce flowering reduced the ability of their cuttings to root in the presence of F. roseum at 80°F. Moreover, some clones were less subject to attacks by this fungus than others. The method, via modification, holds promise as a potential screening procedure for selecting plants suitable for further study in an effort to obtain those resistant to F. roseum as well as other soil pathogens.

Systemic Insecticides Add a New Dimension to Virus Control - H. D. Wells, D. B. Leuck, E. W. Beck, and I. Forbes

The adverse effects of bean yellow mosaic virus (BYMV) on seed production of yellow lupine, Lupinus luteus L., resulted in the yellow lupine acreage in the Southern United States dropping from over 200,000 acres to less than 1,000 acres from 1950 to 1962. BYMV is seed-borne in yellow lupines (5 - 10 percent of seed from diseased plants carry the virus). Secondary spread of the virus by aphids usually resulted in 80 - 100 percent of the plants showing symptoms by flowering time. All seed stocks were contaminated and no genetic source of resistance to the virus could be located in the species. The only hope for reviving yellow lupine culture hinged on finding methods of developing and maintaining sources of virus-free seed.

Early tests with a wide range of insecticides for controlling the aphid vectors, and thus the secondary spread of the virus, indicated that systemic insecticides gave protection for longer periods than other insecticides. Isolated fields planted with BYMV-infested yellow lupine seed (approximately 7%) were treated at monthly intervals with systemic insecticides. The reduction in secondary spread of the virus was phenomenal as compared with the spread in an untreated field. Systemic insecticide treatments plus roguing the virus-infested plants resulted in the production of virus-free seed in two generations.

The Georgia Crop Improvement Association has established standards requiring the use of systemic insecticides for the control of BYMV in the production of foundation and certified Weiko III yellow lupine seed.

CROP PHYSIOLOGY

Henry A. Fribourg, Tennessee, Presiding

Inter-relationships of environmental factors and management on forage crop performance and longevity with specific reference to:

Alfalfa - G. M. Prine

The bare soil environment in which alfalfa seed is placed at seeding is often the severest environment to which the alfalfa plant is exposed. So obtaining a satisfactory stand of alfalfa seedlings is often the most difficult task facing the research worker and farmer. As good seed are necessary for obtaining good stands it seems desirable to discuss some recent findings about alfalfa seed which can effect their germinating ability.

At Florida, Drs. S. H. West and H. C. Harris plagued with poor stands of alfalfa in pots and greenhouse began to investigate to find the reasons for the poor stands. They found when alfalfa seed were separated on basis of color into dark and light seeds that the germination of dark seeds was much lower than light seeds. Also the growth rate of the seedlings from dark seed was slower, especially root growth. The poor germination and seedling growth was traced to an unknown inhibitory substance in the dark seeds. The light colored seed slowly turn dark colored in storage. Further investigation is underway to determine the effect of the various environmental factors on the germination inhibiting substance in alfalfa and other legume seeds and to isolate and identify the germination inhibiting substance.

A survey of alfalfa problems in the South by the alfalfa Subcommittee of the S-47 Technical Committee indicated that maintaining a long lived stand was the principal problem. Many reasons for the poor persistence of alfalfa were given, principally listed were diseases, insects, improper liming and fertilization, poor cutting and grazing management.

In Florida, alfalfa is for all practical purposes an annual. No management practice or practices have been found which will maintain satisfactory stands over one year. However, a number of management practices have been found which tend to increase persistence of alfalfa. Cutting forage high (4 inches) instead of low (1.5 inches) increases persistence, apparently due to the greater photosynthetic leaf area reducing drain on stored food reserves and development of axillary buds on stem in addition to crown buds. Also, the shading by the higher stubble tends to reduce temperatures of soil surface and lower plant parts. Good weed control has also resulted in a higher persistence rate of alfalfa. Alfalfa plants were most persitent when cut at monthly intervals. Longer cutting periods were not favorable as leaf diseases generally partially defoliated the plants after one month.

The reason or reasons why alfalfa is so short lived in Florida is unknown. Studies of the available carbohydrate root reserves have shown that these reserves decrease slowly over the warm humid summer, reaching extremely low levels by late summer. The long humid warm season with rather high night temperatures is undoubtedly a contributing factor to poor persistence of alfalfa.

Alfalfa resulting from a recurrent selection program conducted by E. S. Horner shows improved persistence in Florida. It appears that a successful long-lived alfalfa in Florida depends upon development through breeding or introduction of an alfalfa strain better adapted to climatic and soil conditions, than alfalfa currently available.

<u>Crimson clover</u> - W. E. Knight

Crimson clover, <u>Trifolium</u> <u>incarnatum</u> L. has long been recognized as a versatile widely adapted winter annual legume in the southern region as well as in the coastal section of the western states. This crop has been described as one of the most used annual winter legumes for grazing. Its greatest use is in permanent pastures rather than with temporary grazing crops of rye or oats. Adams and Stelly (2) estimated that 60% of the acreage planted to Coastal Bermudagrass in the Piedmont of Alabama, Georgia,

and South Carolina was seeded to crimson clover. In spite of the wide adaptation and versatility of crimson clover, reports of weakened stands and stand failure have increased in recent years. This report covers some of the work regarding factors affecting the performance of crimson clover. These factors will be covered in three phases. (1) Factors affecting stand establishment and survival. (2) Factors affecting growth, flowering, and seed production. (3) Factors affecting stand longevity.

I. Factors affecting stand establishment and survival

1. Moisture: Considered to be the primary limiting factor in the production of crimson clover seeded in the late summer or early fall. In a 9-year study, crimson clover seeded on September 1 was successfully established each year and produced the highest yield of forage.

2. Temperature: High temperature in the summer and fall does not appear to be detrimental to germination and establishment except as related to soil moisture. In a study at State College, Mississippi, temperature became limiting in November and produced serious effects on November 15 and December 1 seedings.

3. Quantity of seed: Under unfavorable conditions successive stands of clover may be lost. This may be caused by insufficient moisture or an outbreak of insects. Under these conditions, 30 pounds of clean seed per acre have failed to produce productive stands.

4. Hard seed: Soft-seeded clover may produce better stands when seeded under optimum conditions. Under less than optimum conditions, the hard seeded varieties were superior.

5. Insects: Grass worms probably account for more stand losses in the fall than drought.

6. Competitive effects: Volunteer stands of seedlings may be lost from competition from grass and weeds unless precautions are observed.

II. Factors affecting growth, flowering and seed production

1. Moisture: In October 1962, Autauga crimson clover made 726 pounds of green forage per acre in one week and Frontier produced 847 pounds in the same time. Moisture was adequate and temperature had not become limiting.

2. Temperature: Late stands are subject to heaving; early stands are subject to freeze damage unless utilized; growth is negligible when night temperature reaches 40°F.

3. Light: Interaction between light and temperature has been observed. Crimson clover requires "pre-conditioning" for flowering.

4. Stand density: The effect of stand density on early forage growth has been observed in several tests. Crimson clover grows off in direct relation to thickness of stand and the thicker stands produce highest yields. Results from a reseeding study indicate that a minimum of 40 pounds of seed is required for adequate reseeding stands.

5. Defoliation: Moisture and temperature greatly effect production of crimson clover in the spring under defoliation by clipping or grazing. Late spring defoliation by clipping caused severe reductions in forage and seed yields.

6. Insects: The grass worm species cause greatest damage to clover in the seedling stage. Seed weevils do extensive damage to the crop in the spring.

7. Diseases: Crown rot, *Sclerotinia trifoliorum* Eriks; and sooty blotch, *Cymadothea trifolii*, are the two major diseases. Management assists in the control of crown rot since removal of excess growth reduces damage from the disease.

8. Soil fertility: Neglect of this one factor undoubtedly explains many of the losses of stands. Potash has been shown to be the limiting element in a number of studies particularly in association with highly nitrated grasses. Lime and boron have been required for top performance in other tests.

III. Factors affecting longevity:

Since crimson clover is an annual, the main factors effecting longevity are primarily those which effect reseeding. The management and cultural practices which have the greatest influence on reseeding are: (1) use of high quality certified seed of a reseeding variety, (2) controlled grazing, (3) insect control, and (4) soil fertility.

Summary

Good management of crimson clover now recognizes the importance of several environmental factors. Recommended cultural practices are based on known responses of the crop in a given environment. Seeding date recommendations take into account moisture and temperature. Controlled grazing must be practiced and seed weevils controlled to assure adequate supplies of seed for volunteer stands. Fertility requirements must be met with particular attention to the needs of clover grown with highly nitrated summer grasses such as Coastal Bermudagrass and bahiagrass. Competitive effects of weeds and grasses may have to be eliminated by grazing or clipping for successful establishment of volunteer stands.

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<u>Orchardgrass</u> - R. E. Blaser and R. H. Brown

The production of new tillers is thought to be associated with the longevity and dry matter production of orchardgrass. The life history of tillers under various environments is not yet known, but the longevity appears to be less than a growing season. Tillering was directly reduced as the light intensity was decreased from full daylight to 50 and 25% of daylight. Tillering increased as stubble height was increased when cut from 1-1/2 to 3 to 6 inches in height. Tillering improved more with full light intensity-high stubble heights than with the low light intensities-high stubble cutting heights. Tillering was increased as nitrogen fertilizer was increased at a rate from 0 to 200 pounds per acre; but there was no further increase with 400 pounds on N. Tillering was very inferior in the absence of nitrogen fertilizer.

Dry matter production was closely associated with tillering. The soluble carbohydrates in stubble were directly associated with light intensity and cutting heights, but reduced with nitrogen fertilizer. The data suggest that tillering is allied with carbohydrate reserves.

Liberal nitrogen fertilization during the summer months often kills as much as 90% of an orchardgrass stand. Mortality may be associated with the combined effects of stimulated respiration, a reduction in carbohydrate reserves, osmotic effects in

the soil, and stage of growth when cutting orchardgrass.

White clover - E. G. Beinhart

For this discussion, three sectors of "environment" were distinguished, two external factors, the physical (temperature, light, soil moisture, etc.), and biological (nematodes, fungi, insects, etc.); and the internal environment (poorly defined as the sum of interacting plant physiological processes).

The relationships of these concepts of environment to pasture management were discussed on the following basis. Forage yield is a function of leaf production which, in any given environment, tends to be proportional to the number of active leaf-producing meristems. Stolon branching is the most important means of increasing the population of such meristems in a pasture sward. Environment directly affects meristem populations in two ways: (a) by influencing branching rates, environment determines the relative tendency toward population increases; and (b) unfavorable environments cause extensive losses of stolon tissue, thus decreasing meristem populations. Under our conditions, stolons appear to be very short-lived; consequently, branches directly influence persistence as well as yield. Summer is the least favorable season for white clover in the South; our observations suggest that this is the result of drastic reductions in meristem populations.

The following summary of seasonal trends is based on evidence from plants grown in the field and in growth chambers. While admittedly over-simplified, it has proven quite useful as an aid to further studies of environmental effects on growth and persistence.

Spring: Characteristically the season of maximum growth; meristem population increases.

- physical environment favorable
- biological environment not yet unfavorable
- internal environment very favorable as evidenced by rapid leaf production as well as extensive branching

Summer: Yield declines; meristem population declines moderately to severely. Stand losses may be severe.

- physical environment ranges from favorable to definitely unfavorable
- biological environment unfavorable; insects, nematodes, etc., kill many active and potentially active meristems, causing severe losses among meristem populations
- internal environment favorable for active meristems but axillary buds emerge slowly so that few new meristems are available to offset losses.

Autumn: Yield tends to increase above summer levels, but seldom reaches that of spring; meristem population may decline further or may increase.

- physical environment favorable; similar to spring although usually drier
- biological environment generally remains unfavorable until cold weather; insect predations usually are evident and cause further meristem losses

- internal environment favorable, with increased branching rates as early as mid-September in Clemson. Stand survival may well depend on the relative rates of new meristem activation (branching) and losses (insects, etc.) during this period.

Winter: Generally characterized by low yield; meristem populations increase.

- physical environment (viz., low temperature) limits growth rate; freezing of plant tissue and soil heaving sometimes cause serious stand losses
- biological environment appears to be of little importance
- internal environment is unfavorable as evidenced by low rates of leaf production but favorable to the extent that axillary buds become active at most nodes, thus increasing meristem populations and setting the stage for rapid growth and high yields in the spring

According to this interpretation, therefore, the essential goal of management is to maintain an adequate population of active vegetative meristems. Measures taken to achieve this goal should be based on an understanding of environmental effects on the meristematic population. The concept of biological environment is particularly stressed because, (1) it appears to be the most important cause of summer losses and (2) it is probably the most easily modified sector of the total pasture environment.

Bermudagrass - G. W. Burton

Choice of variety is one of the most important decisions involved in pasture management. All other management practices are related to the variety and will be effective only to the extent that the variety will respond to them.

Coastal bermudagrass, that often produces twice as much as common bermuda, has under a severe drought produced over six times as much forage as the common type. Because of its great drought resistance, Coastal bermuda makes little response to irrigation in Georgia unless fertilized with 400 or more pounds of nitrogen per acre per year.

About 65°F. appears to be the minimum temperature for bermudagrass growth. Observations suggest that temperatures as high as 115°F. are not excessive where water is available.

Reducing light with shades reduced yields, total available carbohydrates, sod reserves, and in extreme cases survival of Coastal bermudagrass. Protein content increased as yields decreased, indicating that nitrogen uptake was less reduced by shade than yield.

Nitrogen fertilization of Coastal bermuda up to 900 pounds of nitrogen per acre per year has increased dry matter yields (over 13 tons per acre), protein and carotene content, and palatability. It has reduced nitrogen-free extract and has had no effect on fiber and lignin content.

Extending the period between cuts up to six weeks increased yields and fiber

and lignin content of Coastal bermuda. It decreased carotene and protein content, digestibility, palatability, and daily gains. Annual Coastal bermuda yields were constant at 6-, 8-, and 12- week cutting intervals and were reduced when cut only once at the end of the season. Cutting frequency did not affect longevity. Coastal bermuda maintained good stands for three years when mowed at a height of 1/4 inch with a golf greens mower at daily or 2-day intervals.

Burning of dead Coastal bermuda stubble in late February just as spring growth starts has given effective control of winter weeds and spittlebug.

Coastal bermuda has shown high tolerance of 2,4-D and Simazine. Two pounds of 2,4-D or three pounds of Simazine per acre applied immediately after sprigging Coastal bermuda have given good weed control and greatly hastened establishment.

Many legumes have been successfully grown with Coastal bermuda on land adapted to them. Adequate amounts of lime, phosphorus, potassium, and sometimes minor elements are required. Legumes grow best on Coastal bermuda not fertilized with nitrogen.

At the Georgia Coastal Plain Experiment Station, Coastal bermuda fertilized with 100 pounds of nitrogen per acre per year for five years and set stocked at 1.5, 2.0, and 2.5 600-pound steers per acre gave daily gains of 1.47, 1.31, and 1.15 pounds and per-acre gains of 350, 419, and 454 pounds, respectively. This demonstrates that daily gains on Coastal bermuda can be improved with reduced stocking rates that allow considerable grass to accumulate during the summer.

Southern forage grasses - O. C. Ruelke

A brief resume of Florida studies of inter-relationships of environmental factors including soil fertility, soil moisture, temperature, light, slope, growth regulators, and management on forage crop performance and longevity with special reference to southern forage grasses is presented. Forage yields were significantly increased by proper fertilization, but stands were reduced by winter injury following high nitrogen fertilization. Balanced fertilization, growth regulators and proper grazing practices have been shown to improve forage crop performance and longevity.

Red clover - W. A. Kendall

In areas of our southern states in which red clover is managed as a perennial crop the greatest loss in stands occurs during summer months. Stand losses are exceptionally large if the tops are harvested prior to relatively hot and/or dry weather.

The carbohydrate content of the roots of red clover plants growing in the field is known to decrease after each harvest and does not start to increase until after considerable new top growth has been formed. If top growth is delayed after harvesting by hot and/or dry climate conditions then the carbohydrate level may become too low to enable the plants to persist.

Harvesting the tops of red clover plants may cause a decrease in heat and drought tolerance and in resistance to diseases. Our understanding of the physiological process within the plants as influenced by climate and management practices is improving. This information should help in formulating management practices and in the breeding programs resulting in longer lived red clover.

Business Session

The concluding business meeting of this conference convened at 4:00 p.m., with chairman, R. M. Patterson, presiding. Chairman Patterson acknowledged the splendid cooperation and help of the program committee, P. B. Gibson, C. B. Browning, A. J. Fribourg, and H. D. Wells. Appreciation was expressed to the tours committee, G. H. Rollins, and D. G. Sturkie, the staff of the various departments who participated, and the graduate students who were so helpful in making the tours successful. Chairman Patterson also expressed appreciation to the local arrangements committee who worked diligently on the program, tours, transportation, and the banquet. Chairman Patterson acknowledged the many contributions of retiring executive committee member, M. E. McCullough, who has been active in the conference for the past several years.

The nominating committee, C. V. Browning, R. E. Blaser, and M. S. Offutt, Chairman, presented the name of Dr. W. B. Anthony from Alabama as nominee for new executive committee member. It was moved and seconded that the nominations be closed and that the secretary be instructed to cast a unanimous ballot for Dr. Anthony, motion passed. Following the usual pattern of accession the new elected executive committee member is elevated to conference chairman in 1966.

Chairman Patterson announced that the executive committee had received a letter from the Director of the Florida Agricultural Experiment Station inviting the Southern Pasture and Forage Crop Improvement Conference to hold their 1964 meetings in Florida. Motion that the University of Florida invitation be accepted passed unanimously. April 22 and 23 have been set for the 1964 meetings.

The resolutions committee, L. H. Taylor, M. E. McCullough, and W. E. Knight, Chairman, reported as follows: Be it resolved the Southern Pasture and Forage Crop Improvement Conference members deeply appreciate the hospitalities extended and facilities furnished them during their 20th meeting at Auburn University. Thanks are especially offered to R. M. Patterson, local chairman, Auburn University staff members, and to all of the conference officers for their part in making this conference a success.

Be it further resolved the Southern Pasture and Forage Crop Improvement Conference give special thanks and appreciation to Director R. D. Lewis, who was formerly liaison between the Southern Directors and the SPFCIC and that the conference secretary be authorized to write an appropriate letter to Director Lewis citing him for his faithful service to the conference.

And be it resolved the Southern Pasture and Forage Crop Improvement Conference members give special praise to our Secretary, D. E. McCloud, for his efforts in publishing the minutes of the meetings and other official duties.

We move these resolutions be recorded in the minutes of the meeting and a letter of thanks and appreciation be sent to Dean and Director Smith and local Chairman Patterson of the host institution.

Report of the resolutions committee accepted with enthusiastic acclaim by conference members.

Chairman Patterson expressed his gratitude for the opportunity to work with the group and for all of the members who helped make his job much easier. He then turned over the meeting to incoming Chairman, Dr. O. C. Ruelke, who expressed appreciation for the entire Southern Pasture and Forage Crop Improvement Conference membership to all of those at Auburn for their fine hospitality and the excellent facilities, which have made this meeting so successful.

Chairman Ruelke appointed a program committee for the 1964 meetings at Florida as follows: Plant Breeding, Ian Forbes, Jr.; Animal Husbandry, W. B. Anthony; Plant Physiology, C. Y. Ward; and Plant Pathology, T. E. Freeman.

Call for business and announcements from the floor yielded no new business. The 1964 conference chairman, O. C. Ruelke introduced his executive staff as follows: Past-past Chairman, M. S. Offutt (1964); Past-chairman, R. M. Patterson (1965); Incoming-chairman, C. Y. Ward (1967); New executive committee member, W. B. Anthony (1968); Permanent secretary, D. E. McCloud.

After announcement on transportation to airport at Columbus, meeting adjourned at 4:35 p.m.

In this the 20th Report of the Southern Pasture and Forage Crops Improvement Conference, it seems appropriate to pay tribute to the past conference chairmen who have done so much to make this conference enjoyable and enlightening.

Conference Chairman	Location	Date of meeting
R. L. Lovvorn	Tifton, Georgia	July 23-24, 1940
G. W. Burton	Raleigh, North Carolina	July 19-22, 1941
H. R. Albrecht	Lexington, Kentucky	May 23-25, 1946
J. H. Bennett	Gainesville, Florida	April 22-25, 1947
O. E. Sell	State College, Mississippi	June 7-9, 1948
T. J. Smith	Raleigh, North Carolina	June 15-16, 1949
C. R. Owen	College Station, Texas	May 2-4, 1950
G. B. Killinger	Auburn, Alabama	April 17-19, 1951
T. H. Rogers	Baton Rouge, Louisiana	April 24-25, 1952
R. C. Potts	Blacksburg, Virginia	June 11-13, 1953
J. K. Leasure	Stillwater, Oklahoma	June 8-11, 1954
D. S. Chamblee	Knoxville, Tennessee	June 14-16, 1955
R. E. Blaser	Experiment, Georgia	May 15-17, 1956
Wayne Huffine	Lexington, Kentucky	June 11-13, 1957
P. B. Gibson	Clemson, South Carolina	June 4-6, 1958
E. C. Holt	State College, Mississippi	June 9-11, 1959
N. L. Taylor	Fayetteville, Arkansas	June 8-10, 1960
M. E. McCullough	Beltsville, Maryland	June 14-16, 1961
M. S. Offutt	College Station, Texas	June 27-28, 1962
R. M. Patterson	Auburn, Alabama	May 1-2, 1963

REGISTRATION LIST - 1963

Name	Address	Affiliation
Alabama		
Andrews, O. N.	Auburn	Auburn University
Andrews, O. N. Jr.	"	" "
Anthony, W. B.	"	" "
Boyd, F. E.	Montgomery	V-C Chemical Corp.
Chapman, Louie J.	Auburn	Auburn University
Cope, J. T.	"	" "
Curl, E. A.	"	" "
Donnelly, E. D.	"	" "
Ensminger, L. E.	"	" "
Evans, E. M.	"	" "
Gudauskas, R. T.	"	" "
Hagler, T. B.	"	" "
Hardee, Joel	"	U. S. Borax-Plant Food Development
Harris, R. R.	"	Auburn University
Holt, M. E.	Birmingham	USDA-Soil Conservation Service
Hoveland, C. S.	Auburn	Auburn University
Johnson, W. C.	"	" "
Jones, A. W.	"	Birmingham News
Jordan, Wayne	"	Auburn University
King, Cooper Jr.	"	" "
Langford, J. W.	Tallahassee	" "
Lyle, J. A.	Auburn	" "
Mays, D. A.	Wilson Dam	TVA
Naftel, J. A.	Auburn	U. S. Borax & Chemical Corp.
Nix, Ronald	"	Auburn University
Patrick, K. H.	"	" "
Patterson, R. M.	"	" "
Rogers, Howard T.	"	" "
Rollins, G. H.	"	" "
Smith, E. V.	"	" "
Sowell, W. F.	"	" "
Sturkie, D. G.	"	" "
Summerour, C. W.	Montgomery	American Potash Institute
Warren, W. M.	Auburn	Auburn University
Wear, J. I.	"	" "
Wilson, C. M.	Fairfield	U. S. Steel Corp.
Wise, Ulay	Montgomery	Spencer Chemical Co.
Arkansas		
Offutt, Marion	Fayetteville	University of Arkansas
Australia		
Hutton, E. M.	Brisbane	C.S.I.R.O., Division of Tropical Pastures, Cunningham Laboratory

Florida

Hodges, E. M.	Ona	Range Cattle Station
Hoerner, E. S.	Gainesville	University of Florida
Killinger, G. B.	"	" "
Kretschmer, A. E.	Fort Pierce	Indian River Field Laboratory
Prine, Gordon M.	Gainesville	Fla. Agric. Experiment Station
Ruelke, O. C.	"	University of Florida
Schank, S. C.	"	" "

Georgia

Beaty, E. R.	Athens	University of Georgia
Burns, R. E.	Experiment	Georgia Experiment Station
Burton, G. W.	Tifton	U. S. Department of Agriculture
Craigmiles, J. P.	Experiment	Georgia Experiment Station
Elrod, J. M.	"	" " "
Forbes, I.	Tifton	U. S. Department of Agriculture
Hart, R. H.	"	" " "
Langford, W. R.	Experiment	Plant Introduction Station
Luttrell, E. S.	"	Georgia Experiment Station
McCullough, M. E.	"	" " "
Morocock, Cooper	Atlanta	Allied Chemical Corp.
Newton, J. P.	Experiment	Georgia Experiment Station
Parker, E. M.	Augusta	Columbia Nitrogen Corp.
Powell, J. D.	Americus	Branch Experiment Station
Schauble, C. E.	Atlanta	National Plant Food Institute
Sill, O. E.	Experiment	U. S. Department of Agriculture
Young, W. C.	Athens	" " "

Kentucky

Kendall, W. A.	Lexington	University of Kentucky
Taylor, N. L.	"	" "
Taylor, Tim	"	" "

Louisiana

Ellzey, H. D.	Franklinton	Louisiana State University
Owen, C. R.	Baton Rouge	" "

Maryland

Graumann, H. O.	Beltsville	U. S. Department of Agriculture
Hanson, A. A.	"	" " "
Henson, P. R.	"	" " "
Leffel, R. C.	"	" " "
McCloud, D. E.	"	" " "
Moore, L. A.	"	" "

Mississippi

Andrews, W. B.	Yazoo City	Mississippi Chemical Corp.
Bennett, H. W.	State College	Mississippi Agric. Exp. Station
Browning, C. B.	" "	" " " "
Hogg, P. G.	Stoneville	Delta Branch Experiment Station
Knight, W. E.	State College	Mississippi Agric. Exp. Station
Kuykendall, R.	Newton	Coastal Plain Experiment Station
Meredith, W. R. Jr.	State College	Mississippi State University
Sanders, T. G.	" "	Mississippi Experiment Station
Ward, C. Y.	" "	Mississippi State University

New York

Buller, R. E.	New York	Rockefeller Foundation

North Carolina

Cope, W. A.	Raleigh	N. C. State College
Dudley, J. W.	"	" " "
Gross, H. D.	"	" " "
Petersen, R. G.	"	" " "
Sherwood, R. T.	"	" " "
Smart, W.W.G., Jr.	"	" " "
Timothy, D. H.	"	" " "

Oklahoma

Bates, D.	Ardmore	Noble Foundation
Simmons, G. D.	"	" "

Puerto Rico

Velez-Fortuno, J.	Rio Piedras	University of Puerto Rico

South Carolina

Beinhart, G.	Clemson	U. S. Department of Agriculture
Chalupa, W.	"	S. C. Agric. Experiment Station
Clapp, J. G.	"	" " " "
Eskew, E. B.	"	Clemson College
Garrison, O. B.	"	S. C. Agric. Experiment Station
Gibson, P. B.	"	Clemson College
Halpin, J. E.	"	" "
Maurer, T. C.	Spartanburg	Soil Conservation Service
McClain, E. F.	Clemson	Clemson College
Stanley, R. L., Jr.	"	" "
Watkins, P. W.	"	" "

Tennessee

Burns, J. D.	Knoxville	University of Tennessee
Gray, E.	"	" "
Fribourg, H. A.	"	" "

Texas

Bashaw, E. C.	College Station	U. S. Department of Agriculture
Holt, E. C.	" "	Texas A & M College
Riewe, M.	Angleton	Texas Agric. Exp. Station
Staten, R. D.	College Station	Texas A & M College
Weihing, R. M.	Beaumont	U. S. Department of Agriculture

Virginia

Blaser, R. E.	Blacksburg	Virginia Polytechnic Institute
Brown, R. H.	"	" " "
Shoulders, J. F.	"	" " "
Taylor, L. H.	"	" " "